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ORIGINAL RESEARCH PAPER

The Effect of Education based on Modeling with COMSOL Simulation Software on Correcting Misunderstandings and Misconceptions of Electricity Physics Concepts

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ABSTRACT

Background and Objectives: The topic of electricity is often considered a challenging and abstract concept in physics. Learning non-intuitive scientific concepts can be challenging for students because they often hold incorrect conceptions about natural phenomena that lead them toward errors. Many students struggle to understand the underlying principles and behaviors of electrical systems. Identifying and correcting misconceptions about electricity physics is essential for promoting meaningful learning and conceptual understanding. Nowadays, using technology in educational settings is considered an essential aspect of teaching and learning. Utilizing technology, such as simulation software like COMSOL, can help to visualize and better understand these concepts. This research has been done with the aim of identifying and correcting the misunderstandings of 11th-grade high school students in learning the concepts of electricity by simulating COMSOL software.

Materials and Methods: The present research is an applied study in terms of its objective and a mixed-methods research in terms of its methodology. The qualitative section utilized content analysis to extract misconceptions about the concepts of electricity in physics. Semi-structured interviews were conducted with SIX teachers using purposive sampling. Three types of coding, namely open, axial, and selective, were employed to extract the main misconceptions. The main misconceptions identified were Coulomb's law, the shape of field lines between two point charges, the electric field between capacitor plates, the motion of electric charges in an external electric field, charge distribution on surfaces, and the effect of an external electric field on conductive and non-conductive shells. Based on this pattern, a 6-item questionnaire was designed to validate the pattern of misconceptions about electricity concepts among students. The validation of the extracted pattern and the content validity of the questionnaire were assessed by experts in the field of physics education. The quantitative section of the research was a quasi-experimental study with a pretest-posttest design and a control group. The target population consisted of all male eleventh-grade students in high schools in Bojnurd city during the academic year 2022-2023. Using random sampling, 30 students were selected for each group. In the first stage, both groups took a pretest. Then, the experimental group received the independent variable (simulation-based learning using the COMSOL software) in six sessions of 90 minutes each. Meanwhile, the control group received traditional lecture-based instruction. After the intervention, both groups (experimental and control) took the dependent variable (the misconceptions test on electricity concepts). The data were analyzed using ANCOVA (Analysis of Covariance) with the help of SPSS software.

Findings: The post-test results showed that in addition to correcting students' misconceptions and increasing their learning level, the use of computer and COMSOL simulation software helped them better understand the concepts and increased their concentration. The results of this analysis showed a significant difference ($p<0.05$) between the learning and progress of the experimental group and the control group. The errors of the experimental group changed significantly compared to the control group. In the topics under investigation, the minimum percentage of misconception correction in the experimental group was 46.66%. Meanwhile, the minimum percentage of misconception correction in the control group was observed to be 36.66%.

Conclusions: The research results have demonstrated that Simulation software enables students to visualize and interact with abstract concepts, making them more tangible and easier to comprehend. By using COMSOL, students can manipulate different variables in electrical systems, observe the effects, and gain insights into the underlying principles. This hands-on approach can correct misconceptions and improve students' understanding of electricity in physics. By providing interactive and visual representations of electrical phenomena, simulation software can make the subject more accessible and engaging, leading to improved learning outcomes. According to the obtained results, it is suggested that educational technology and modeling using COMSOL software be promoted in teachers' professional development programs. This action can lead to the development of knowledge of educational content and the correction of misunderstandings of concepts.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
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مقاله پژوهشی

تاثیر آموزش مبتنی بر مدل‌سازی با نرم‌افزار شبیه‌ساز کامسول بر اصلاح سوء تفاهم‌ها و کج فهمی‌های مفاهیم فیزیک الکتریسیته

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چکیده

پیشینه و اهداف: موضوع الکتریسیته اغلب یک مفهوم چالش برانگیز و انتزاعی در فیزیک در نظر گرفته می‌شود. یادگیری مفاهیم علمی غیر شهودی می‌تواند برای دانش آموزان چالش برانگیز باشد، زیرا آنها اغلب تصورات نادرستی در مورد پدیده‌های طبیعی دارند که آنها را به سمت خطا سوق می‌دهد. شناسایی و اصلاح باورهای غلط فیزیک الکتریسیته برای ارتقای یادگیری معنادار و درک مفهومی ضروری است. امروزه استفاده از فناوری در محیط‌های آموزشی یکی از جنبه‌های ضروری آموزش و یادگیری محسوب می‌شود. استفاده از فناوری مانند نرم‌افزار شبیه‌سازی کامسول می‌تواند به تجسم و درک بهتر این مفاهیم کمک کند. این تحقیق با هدف شناسایی و اصلاح سوء تفاهمات دانش‌آموزان پایه یازدهم در یادگیری مفاهیم الکتریسیته با شبیه‌سازی نرم‌افزار کامسول انجام شده است.

روش‌ها: روش پژوهش حاضر از نظر هدف یک پژوهش کاربردی و از نظر نوع روش، یک تحقیق ترکیبی است. بخش کیفی با روش تحلیل محتوا با هدف استخراج مقوله‌های کج فهمی‌های فیزیک الکتریسیته انجام گرفته است. در این راستا، از پروتکل مصاحبه‌های نیمه ساختار یافته از ۶ معلم با روش نمونه‌گیری هدفمند استفاده گردید. در این بخش از پژوهش، از سه نوع کدگذاری باز، محوری و انتخابی استفاده گردید. مقوله‌های اصلی کج فهمی‌ها از این نوع کدگذاری استخراج گردید. مقوله‌های اصلی الگوی سوء تفاهم‌های مفاهیم فیزیک الکتریسیته عبارت شدند از: قانون کولن، شکل خطوط میدان بین دو بار نقطه‌ای، میدان الکتریکی بین صفحات خازن، حرکت بار الکتریکی در میدان الکتریکی خارجی، توزیع بار روی سطوح و اثر میدان الکتریکی خارجی بر روی پوسته‌های رسانا و نارسانا. براساس این الگو، پرسشنامه ۶ سوالی برای اعتباریابی الگوی سوء تفاهم‌های مفاهیم فیزیک الکتریسیته دانش‌آموزان طراحی گردید. برای اعتباریابی الگوی استخراجی و روایی محتوایی پرسشنامه از نظر متخصصان حوزه اموزش فیزیک استفاده شد. بخش کمّی پژوهش حاضر یک تحقیق شبه آزمایشی با طرح پیش آزمون- پس آزمون با گروه کنترل بود. جامعه آماری کلیه دانش‌آموزان پسر پایه یازدهم دبیرستان شهر بجنورد در سال تحصیلی ۱۴۰۱-۱۴۰۲ بود. با بهره‌گیری از روش نمونه‌گیری تصادفی، ۳۰ دانش‌آموزان برای هر گروه انتخاب شدند. در مرحله اول از هر دو گروه پیش آزمون به عمل آمد. سپس بر روی گروه آزمایش، متغیر مستقل (آموزش مبتنی بر مدل‌سازی با نرم‌افزار شبیه‌ساز کامسول) طی ۶ جلسه، ۹۰ دقیقه‌ای انجام شد. همزمان، در گروه گواه از آموزش سنتی (سخنرانی) استفاده گردید. پس از مداخله، بر روی هر دو گروه (آزمایش و کنترل) متغیر وابسته (آزمون سوء تفاهم‌های مفاهیم فیزیک الکتریسته) اجرا شد. داده‌ها با استفاده از روش آماری تحلیل کوواریانس با کمک نرم‌افزار SPSS مورد تجزیه و تحلیل قرار گرفت.

یافته‌ها: نتایج پس از آزمون نشان داده‌اند که استفاده از کامپیوتر و نرم‌افزار شبیه‌سازی کامسول، بهبود قابل توجهی در تمرکز دانش‌آموزان، اصلاح کج‌فهمی و افزایش سطح یادگیری آن‌ها داشته است. همچنین، این روش به دانش‌آموزان در درک بهتر مفاهیم کمک کرده است. نتیجه حاصل از این تجزیه تحلیل نشان داد که میزان یادگیری و پیشرفت دانش آموزان گروه آزمایش نسبت به گروه گواه تفاوت معناداری دارد ($p<0/05$). اشتباهات گروه آزمایش نسبت به گروه کنترل به‌طور قابل توجهی تغییر کرده است. در مباحث مورد بررسی کمترین درصد اصلاح کج فهمی

در گروه آزمایش ٪۴۶/۶۶ می‌باشد. در حالی که کمترین درصد اصلاح کج فهمی در گروه گواه ٪ ۳۶/۶۶ مشاهده شده است.
نتیجه‌گیری: نتایج پژوهش نشان داده‌اند که با استفاده از نرم‌افزار شبیه‌سازی کامسول، دانش‌آموزان قادر به تصویرسازی و تعامل با مفاهیم انتزاعی می‌شوند که آنها را قابل درک‌تر و قابل فهم‌تر می‌کند. با استفاده از کامسول، دانش‌آموزان می‌توانند متغیرهای مختلف در سیستم‌های الکتریکی را تغییر داده، تأثیرات آن را مشاهده کرده و به اصول پایه آن بیشتر آگاه شوند. این رویکرد عملی به دانش‌آموزان در اصلاح کج‌فهمی‌ها و بهبود درک آنان از الکتریسیته در فیزیک کمک می‌کند. با ارائه نمایش تعاملی و تصویری از پدیده‌های الکتریکی، نرم‌افزار شبیه‌سازی موضوع را قابل دسترس و جذاب می‌سازد و در نتیجه، بهبود عملکرد و یادگیری دانش‌آموزان را به همراه دارد. بر اساس نتایج بدست آمده، پیشنهاد می‌شود که فناوری آموزشی و مدل‌سازی با استفاده از نرم‌افزار کامسول در برنامه‌های توسعه حرفه‌ای معلمان ترویج یابد. این اقدام می‌تواند به توسعه دانش محتوای آموزشی و اصلاح کج‌فهمی مفاهیم کمک کند.

Introduction

According to the theory of constructivism, students, upon entering each new stage or educational situation, bring with them a set of conceptions based on their prior experiences and knowledge. Prior to entering the classroom, students have ample opportunities to form various and sometimes incorrect mental models and conceptions about the surrounding world and scientific phenomena [1]. Many of these mental conceptions held by students are the result of their daily experiences, observations of scientific phenomena, and the application of science and technology in human life. These misconceptions are referred to as ‘misconceptions’ or ‘misunderstandings’.

Misconception is defined as any type of unfounded belief that does not include fear, luck, faith, or metaphysical interference. Misunderstanding is caused by people's incomplete and faulty reasoning. Some of the attitudes that students use to make sense of the world are partial and incomplete truths and are called misunderstandings. Misunderstanding is a knowledge structure that is activated in various contexts is resistant to change and is not compatible with accepted scientific knowledge [2].

When these misconceptions are addressed in the classroom, they appear as preconceived notions or prior learning, influencing the learning process [3]. Some of these conceptions may be completely different from or in contradiction with accepted scientific principles, and students may struggle to provide accurate explanations of scientific phenomena due to these misconceptions. Many researchers around the world focused on identifying and correcting students' misconceptions in various subjects. Researchers describe these misconceptions using different terms such as misconceptions, misunderstandings, naive conceptions, alternative conceptions, or preconceptions. It is crucial for educators to be aware of the common misconceptions that students may hold and actively work on to help students overcome these misconceptions [4]. By identifying misconceptions educators can guide students toward a more accurate understanding of scientific principles and promote deeper learning. To address misconceptions, educators can implement various strategies such as formative assessments, concept mapping, hands-on activities, and targeted questioning. These approaches encourage students to actively engage with the subject matter, identify their misconceptions, and reconstruct their understanding based on evidence and scientific principles [5-6]. Misconceptions in understanding the concepts of the subjects can arise from incorrect teaching by instructors. Some instructors may face difficulties in conveying the material to learners due to preconceived notions (which may be personal interpretations or what they learned from their own teachers). These difficulties lead to learners' aimless and unfocused mental engagement. Therefore, researchers recommend that educational authorities provide the necessary training for instructors and mentors to ensure proper teaching practices [7]. This issue becomes particularly important when dealing with abstract concepts [8].

Physics is one of the subjects that can create misconceptions for students due to its difficulty and the use of specialized and conceptually rich vocabulary. The topic of electricity is also considered a challenging and abstract concept in physics [9-11]. By identifying and correcting misconceptions of electricity concepts, educators can create a more effective learning environment that supports students in developing a solid foundation of knowledge and promoting conceptual understanding. By Identification and correcting students' misconceptions, educators can help students develop a more accurate understanding of scientific principles and foster their scientific literacy [12-17]. As a result, teaching electricity in physics poses numerous challenges, and many studies have been conducted to explore suitable instructional strategies for this topic. The past studies done in this field mostly focused on changing teaching methods and inventing new methods to solve the problem of misunderstandings [18-20]. Correcting misunderstandings of physics concepts using simulation software adds to the novelty of the subject. Today, computers help to teach and facilitate education, as well as create opportunities for students in the field of using technology, and are considered useful tools for implementing and improving educational methods. Technology and computers have revolutionized the field of education by providing various tools and resources that enhance the teaching and learning experience. Technology and computers have transformed education by expanding access to information, enhancing learning experiences, promoting collaboration, and providing personalized learning opportunities [21]. They continue to shape the education landscape, make it more accessible, engaging, and effective. Educational technology and computers have become invaluable tools in modern education. They offer numerous benefits and opportunities for both students and educators [22].

The topic of electricity is one of the very important concepts that are discussed in science books in the pre-university and university levels. By providing students with a visual representation of scientific principles, they can better understand and correct their misconceptions. Considering the importance of physics concepts and misunderstandings related to this field, using COSMOL software [23] to model and correct misconceptions related to electricity in physics could be an effective approach. The purpose of this research is to correct the misunderstandings of the concepts of electricity physics by using modeling with the help of COSMOL software.

Review of the Related Literature

Due to the mental nature of human beings, every person has various misunderstandings. Distortion of a concept in itself is not considered a misunderstanding, but it may cause misunderstanding. In conveying a concept to others, each person may choose only one set of information to present, but the receiver can imagine other concepts about the presented concept that may be incorrect. There are different types of misunderstanding, the most common of which are briefly defined here [9]

- Preconceived concepts: general concepts that are rooted in everyday experiences.
- Non-scientific beliefs: includes concepts learned by students from sources other than scientific education such as stories or legends.
- Perceptual misunderstandings: when students have learned scientific information in such a way that even if this information is in conflict with their previous ideas and non-scientific opinions, they do not pay attention to the interpretation and find the cause of the conflict and to get rid of the generated mental confusion provides weak models. These models are so weak that the students themselves are not sure enough about their concepts.
- Verbal misunderstandings: This category of misunderstandings is caused by the use of words that have one meaning in everyday life and another meaning in the scientific field.
- Practical (real) misunderstandings: This category of misunderstandings are mistakes that are made at a young age and are completely preserved in adulthood.

What leads to misunderstanding in the minds of students is simplistic in the learning process. The misunderstanding is a concept that is not in agreement with our current understanding of nature and is a private version of students' understanding [10]. In other words, misunderstanding is used for a situation in which the idea that people make of a concept in their mind is in conflict with the ideas of the experts of that science. This situation is different from the situation where an inadvertent error occurs due to ignorance. Misunderstanding causes systematic conceptual errors; that is, mistakes that happen in similar situations [12]. Identifying and correcting misunderstandings about different scientific concepts is one of the common research in the field of education. Researchers in the field of physics education have investigated common misunderstandings related to the electricity concept, which are mentioned below.

In a 2023 study, Siong et al. investigated the use of conceptual cartoons in overcoming misconceptions about electrical concepts to improve students' understanding of direct current circuits. The results of this research showed an increase in students' conceptual understanding after using conceptual cartoons [5].

In a 2022 study, Mason et al. examined how critical thinking skills affect misconceptions in the electrical field. The study was conducted with the aim of determining the effect of critical thinking skills on false beliefs using a five-layer tool in mixed research. The descriptive results of critical thinking skills data show that the average of critical thinking skills is 68.50, which means that students' critical thinking skills are in a good status [24].

In a 2019 study, Moodley et al. investigated teachers' perceptions and learners' misconceptions about electrical circuits education. In this research, an exploratory case study involving six 9th-grade science teachers was conducted to examine how teachers' understanding of learners' misconceptions is related to their understanding of teaching simple circuits. The results were analyzed using content analysis and interpreted using educational content knowledge. The results showed that the understanding of learners' misconceptions is not always related to the conceptual understanding of electrical circuits education. While a fair understanding of misconceptions was shown by teachers who had studied physics at the undergraduate level, only those who also had a degree showed a conceptual understanding of electrical education. Teachers who had not studied science education revealed technical perceptions, focusing on facts, demonstrations, and calculations [25].

In a 2018 study, Nancevici et al. investigated neural correlations related to the correction of errors by novices in the fields of electricity and mechanics. According to their report, recent studies have shown that students with advanced scientific training use brain areas related to inhibitory control and memory retrieval to avoid making mistakes for questions related to non-intuitive scientific concepts. The results of this research show that the frontal and parietal regions of the brain are more active after correcting errors than before. These findings show that novice error correction mechanisms, which are established by providing correct answers to learners at the very beginning of the learning process, are related to memory retrieval, but not to inhibitory control [26].

In a 2018 study, Asghari et al. investigated the use of the conceptual change model in teaching basic physics concepts and correcting misconceptions. This study was conducted with the aim of investigating the effectiveness of the Conceptual Change Model (CCM) in learning the basic concepts of electrostatics. CCM is an active learning method that emphasizes children's anticipation. The underlying principles of CCM are derived from constructivist theory. The findings of the research showed that the CCM teaching methods are superior to the traditional teaching and learning methods of physics concepts in detecting and correcting misconceptions [27].

In a research in 2017, Hermita et al. developed and implemented a four-tier test on static electricity to detect the misconceptions of pre-service elementary school teachers. They already developed and implemented a diagnostic test composed of four levels to detect elementary school teachers' false beliefs about static electricity. The method used in this research was three-dimensional (definition, design, development, and implementation) done for pre-service elementary teachers. The results of this research show several misconceptions regarding the concept of static electricity. In addition, the results of the research show that the diagnostic test is able to analyze the number of false beliefs and classify the level of understanding of elementary school teachers, which is scientific knowledge, misconception, lack of knowledge, and error [28].

In a 2014 study, Guyer investigated teachers' awareness and planned correction of learners' misconceptions about electrical circuits. This paper reports an exploratory multi-case study of how science teachers understand and intend to address learners' misconceptions about electrical circuits. The results indicate that teachers' understanding of students' misconceptions is related to their own subject knowledge. Furthermore, this study showed that the technique of asking teachers about learners' anticipated responses is a promising way to examine teachers' understanding of learners' misconceptions and the strategies they use to address these misconceptions [29].

In a research in 2017, Sert Jibik determined the scientific knowledge and misconceptions of science teacher candidates about electric currents. This research had two goals. The first objective is to determine the knowledge (academic success) and misconceptions of science teacher candidates about electric current and the second objective is to compare these results in the academic year and gender of the participants. The results of the study showed that while there is no significant difference between the academic successes of students in terms of electric current based on their academic year, there is a significant difference based on the gender of the participants and men get a better score. The findings also showed that the teacher candidates have many misconceptions, especially related to the concepts of current, electric field, generators, supply EMF, and potential difference. In addition, it was observed that the teacher candidates had wrong ideas about the operation of magnetic fields and energy conversion in power plants, a topic that is discussed in the field of alternating current [30].

In a research in 2013, Shokarbaghani compared the understandings of third-year high school students about the concepts of electricity with undergraduate and graduate students. With the aim of evaluating the understanding of third-grade high school students and undergraduate and graduate students about the concepts of static electricity, he conducted descriptive survey research. The findings of this research show new ideas and misunderstandings about static electricity concepts. Based on these findings, they stated that it is necessary to pay more attention to the revision of physics curricula and teaching materials that are currently being done [31]. In a 2017 study, Ramnaraina et al. investigated the effectiveness of using interactive computer simulations to address misconceptions of South African grade 10 students in electrical circuits. The results of this research showed that simulations may be a suitable cognitive learning tool to enable learners to check their presuppositions and as a result conceptual change [32].

So far, there has been no research on the use of modeling with COSMOL simulation software to correct misunderstandings of electricity physics concepts. COSMOL simulation software allows students to visualize and interact with abstract concepts, making them more concrete and easier to understand. This approach can help correct misconceptions and increase students' understanding of electricity in physics. Considering the importance of electricity in life and the importance of correcting misunderstandings, the purpose of this research is to correct misunderstandings of the concepts of electricity physics by using modeling with COSMOL simulation software.

Method

The current research method is applied in terms of its purpose and mixed research (Mixed methods) in terms of the type of method. It involves administering pre-tests and post-tests in both experimental and control groups.

Participants

The participants of this study were male students at the 10th grade of high schools in the city of Bojnourd during the academic year 2022-2023. The age range of the participants was between 15 and 16 years old. The target population was randomly sampled, and a total of 60 students were selected, with 30 assigned to the experimental group and 30 to the control group.

Instruments

The research study employed a mixed-methods approach, utilizing both qualitative and quantitative instruments to gather the required data. The instruments are divided into two sections: the qualitative section and the quantitative section.

For the qualitative section, the instrument used was semi-structured interviews with six purposively selected teachers. The interviews aimed to extract misconceptions in the physics of electricity. The following details the process: Selection of Participants: Six teachers were purposively selected based on their expertise in physics education.

Semi-Structured Interviews: The interviews were conducted in six 90-minute sessions. The interviewer prepared general and targeted questions in advance, which were provided to the interviewees during the interviews. These questions focused on extracting misconceptions in the physics of electricity.

Content Analysis: Content analysis was employed as the method for analyzing the data obtained from the interviews. Open, axial, and selective coding techniques were used to identify and categorize the main categories of misconceptions in the physics of electricity. The identified categories included:

a) Coulomb's law (interaction between like and unlike charges)

b) Shape of electric field lines for point charges

c) Electric field between capacitor plates

d) Torque on electric dipoles in the presence of an external electric field

e) Charge distribution on surfaces

f) Effect of an external electric field on conductive and non-conductive shells

Expert Validation: To validate the extracted pattern of misconceptions, experts in the field of physics education were consulted.

The quantitative section of the research employed a quasi-experimental design with a pretest-posttest and a control group. The instrument used was a researcher-made questionnaire designed based on the identified main categories of misconceptions in the physics of electricity. Here are the details of the quantitative section:

Questionnaire Design: A 6-item questionnaire was developed, with each question addressing one misconception from the identified pattern. The questionnaire consisted of three main options and one justification option for each question. Each question was scored as either one (no misconception) or zero (misconception).

Content Validity: The content validity of the questionnaire was ensured by subjecting it to evaluation by experts in the field.

Pretest and posttest: In the first stage, both the experimental group and the control group completed a pretest to assess their initial level of misconceptions in the physics of electricity. Following this, the experimental group received the independent variable, which was simulation-based modeling instruction using the COMSOL software, in six 90-minute sessions. The control group received traditional instruction through lectures. After the intervention, both groups took a posttest to assess their level of misconceptions.

Data Analysis: The data collected from the pretest and posttest was analyzed using the statistical method of ANCOVA (Analysis of Covariance) with the assistance of SPSS software.

By employing both qualitative and quantitative instruments, the study aimed to comprehensively explore and measure misconceptions in the physics of electricity and evaluate the effectiveness of the simulation-based modeling instruction in reducing these misconceptions.

Design

To identify misunderstandings, various diagnostic tools are used, the most important of which are interviews, multiple-choice tests, and multiple tests, as conceptual tests. Interviews are considered the most accurate method as they provide in-depth information about students' cognitive patterns and arguments. However, interviews have limitations, such as the need for significant precision, time, and resources, difficulty in organizing and analyzing data, and limited applicability to a large number of students. To overcome the disadvantages of interviews, diagnostic multiple-choice questions have been widely used. These questions are easily scored and applicable to a larger number of students. However, they cannot examine students' arguments in depth and may not capture the full range of students' understanding. The design aimed to evaluate the effectiveness of an instructional program in correcting misconceptions about electricity concepts. It incorporated both qualitative content analysis and quantitative quasi-experimental design techniques.

In the qualitative section, a content analysis is conducted using semi-structured interviews. The purpose of this qualitative component is to identify misconceptions about electricity concepts among the participants. The researchers will conduct interviews with participants to gather qualitative data on their understanding and misconceptions related to electricity.

The quantitative section of the study employs a quasi-experimental pretest-posttest design with a control group. The pretest will establish a baseline measure of the participants' initial understanding of electricity concepts, with participants individually completing a pretest questionnaire before the instructional program. The instructional program will be a six-session program that addresses different aspects of electricity concepts, utilizing simulation modeling activities with COMSOL software. The control group will not receive the instructional program but will undergo the pretest and posttest assessments, providing a basis for comparison to evaluate the effectiveness of the instructional program. The posttest will be administered after the completion of the instructional program to assess the participants' improved understanding.

The rationale for the pretest-posttest design with a control group is to enable a comparison of pretest and posttest scores to evaluate the impact of the intervention on learning outcomes, account for external factors by assessing participants' understanding before the instructional program and using a control group for comparison, and allow for causal inferences by attributing improvements in posttest scores to the instructional program itself. Additionally, this design is relatively straightforward to implement and can be conducted within a reasonable timeframe, providing a robust framework for assessing the effectiveness of the instructional program in correcting misconceptions and improving the understanding of electricity concepts.

By employing this mixed-methods approach, combining qualitative insights through content analysis and quantitative data through the pretest-posttest design, the researchers aim to gain a comprehensive understanding of the impact of the instructional program on participants' knowledge and understanding of electricity concepts.

Procedure

This research provides two separate sections of information for the procedure. The first part describes the procedure for identifying topics with the highest level of misunderstanding among students in the topic of electricity using a triple test. The second part outlines a protocol for remedying misconceptions in the concept of electricity using simulation modeling with COMSOL software.

Procedure for Identifying Misunderstandings in Electricity

Triple Test: A triple diagnostic test was used to identify topics with the highest level of misunderstanding among students in the topic of electricity. The test consisted of 12 three-part questions related to electricity in the physics course.

Test Administration: The test was administered to students in normal classroom conditions, without prior knowledge, and over a period of 90 minutes. In order to reduce the impact of errors due to stress, the students were assured that the test was for research work the answers were checked confidentially, and would not have any effect on their grades.

Structure of the Triple Test: Each question in the test had two parts. The first part included content questions with multiple options, where only one option was correct, and the others were incorrect. The second part included a set of reasons for each option, consisting of the correct reason and common misconceptions. The reasons were derived from students' answers, interviews, and various articles.

Answer Evaluation: Students' answers to each question were considered correct only if they chose both the correct option and the correct reason. If a student gave an incorrect answer in the first part, selected the reason for the same incorrect answer, and expressed confidence in their answer in the third part, it was assumed that the student had a misconception.

Identification of Misunderstandings: The questions that had the highest level of misunderstanding, based on students' responses, were identified. In the designed triple test, the questions that had the highest level of misunderstanding were included in the appendix of the study.

Procedure for Remedying Misunderstandings in Electricity

Design an Educational Program: Develop an educational program specifically designed for eleventh-grade students to address misconceptions in the concept of electricity.

Utilize COMSOL Software: Incorporate simulation modeling with COMSOL software as a tool to aid in remedying the misconceptions.

Content Validity Ratio (CVR): Determine the content validity ratio (CVR) of the protocol to assess its effectiveness in addressing students' understanding. The CVR for this protocol is 75%.

Reliability Assessment: Evaluate the reliability of the protocol by assessing it with evaluators. The reliability coefficient obtained is 80%.

Implement the Protocol: Follow the protocol in the classroom, ensuring students actively engage with the simulation modeling using COMSOL software.

Effective Remediation: The protocol aims to effectively address students' misconceptions, promoting a deeper understanding of the subject matter.

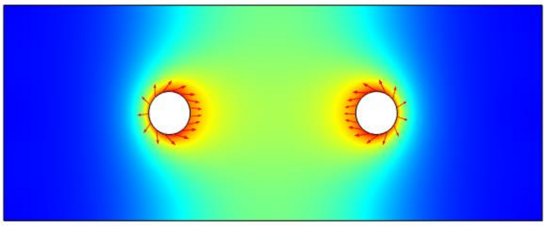
The summary of the instructional program for remedying misconceptions about the concept of electricity using simulation modeling with COMSOL software is depicted in Table 1. Please note that this is a general summary of the instructional program, and detailed descriptions of each session are below.

- Coulomb's law: In this topic, students do not have the ability to analyze the tensile force between two-point loads. According to the answers of the pre-test, it was observed that some students have the wrong idea that identical charges attract each other and dissimilar charges repel each other. The attraction between inhomogeneous charges and repulsion between inhomogeneous charges have created a misunderstanding for students. This idea can be caused by the comparison between different categories of objects or even living things with electric charge, which, just as a dissimilar item has no place in a group, loads also do not tend to have a dissimilar charge next to them.

Table 1: Summary of the educational program for correcting misunderstandings of electrical physics concepts by using modeling with COMSOL simulation software.

Session	Session Title	Session Description
1	Coulomb's law	Modeling and simulation of attraction of unlike charges, repulsion between like charges and introduction to the concept of electricity, and initial assessment of student's knowledge. The simulated output is shown in Figure 1.
2	The shape of the field lines between two point charges	The electric field between two electric charges can be modeled and simulated using various concepts. Here are some key concepts: charge polarity, radial symmetry, field line density, superposition, the field lines of the interaction between the charges, and field line Patterns. The simulated output is shown in Figure 2.
3	The electric field between capacitor plates	Teaching students about the electric field inside a capacitor and using modeling and simulation to help illustrate your points. The electric field lines inside a capacitor are generally perpendicular to the plates and uniformly spaced between them, but they can curve outward near the edges of the plates, indicating a non-uniform electric field in that region. The simulated output is shown in Figure 3.
4	Rotation of a charged particle placed in an external electric field	Modeling and simulating electric systems of a position-charged particle inside an external field and charge polarization using three-dimensional models. The simulated output is shown in Figure 4.
5	Electric charge distribution in pointed objects	Teaching students about charge distribution on an object; and the effect of sharp or pointed features of the object using modeling and simulation. The simulated output is shown in Figure 5.
6	Effect of external electric field on conductive and non-conductive shells	Modeling and simulating the behavior of electric field lines when they encounter conductive and non-conductive shells. The simulated output is shown in Figure 6.

The simulated output for designing two point loads and displaying Maxwell's electric stress tensor (tendency to move in each point load) for each pair is shown in Fig. 1.



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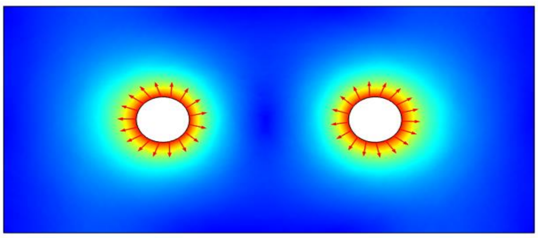


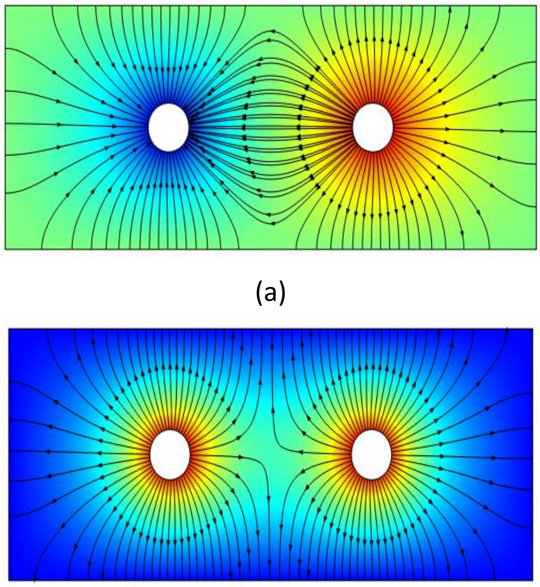
(b)

Fig. 1: shows a) attraction of bases of unlike charges and b) repulsion between like charges

a) Attraction of unlike charges: When two charges of opposite polarity (positive and negative) are brought close to each other, they experience an attractive force. This attraction arises from the interaction of the electric fields generated by the charges. The field lines originating from the positive charge and terminating on the negative charge indicate the direction of the force. The field lines curve towards the opposite charge, illustrating the attractive force between them. This attraction is a fundamental principle in electrostatics and is described by Coulomb's law.

b) Repulsion between like charges: When two charges of the same polarity (both positive or both negative) are brought close to each other, they experience a repulsive force. This repulsion is due to the like charges having the same sign of charge, resulting in the electric fields generated by each charge pushing against each other. The field lines originating from each charge curve away from each other, illustrating the repulsive force between them. The density of the field lines represents the strength of the repulsive force, with denser lines indicating a stronger force. This repulsion between like charges is another fundamental principle in electrostatics and is also described by Coulomb's law.

- The shape of the field lines between two-point charges: In the topic of electric field lines, students often have misconceptions about the direction and placement of the lines between two-point charges. Similarly to the previous topics, it was observed that students mistakenly believe that the direction of the electric field is from a same-sign adjacent charge and that if two opposite charges are placed next to each other, the direction of the field is from the charges towards the surrounding space. By correcting these misconceptions and providing clear explanations and visual aids, students can better understand the behavior of electric field lines and their relationship to point charges. Using simulation output, it has been shown that when two opposite charges are adjacent, the direction of the electric field lines is from the positive charge to the negative charge, and the lines are connected to both electric charges. When two same-sign charges are adjacent, the field lines scatter to the surrounding space. This information can be used to correct students' misconceptions and enhance their understanding of electric field lines (See Fig. 2). For teaching purposes, the movie of charges moving toward each other or away from each other was shown. Showing a movie of charges moving towards each other or moving away from each other twice can be a useful teaching tool. This visual aid can help students better understand the behavior of electric field lines and the direction of the field between point charges. By combining visual aids with clear explanations, educators can create a more effective learning environment and help students develop a solid foundation of knowledge in electricity and physics.



(a)

(b)

Fig. 2: Field lines caused by (a) two unlike point charges, (b) two like point charges

Fig. 2 shows the field lines between two-point charges a) unlike b) like. The field lines between two unlike point charges and two identical point charges are different in their patterns.

Non-Identical Point Charges: When two non-identical point charges are present, such as a positive charge and a negative charge, the field lines originate from the positive charge and terminate on the negative charge. The number of field lines originating from the positive charge is greater than the number terminating on the negative charge, reflecting the difference in their magnitudes. The field lines are closer together near the charges with stronger magnitude, indicating a higher field strength, and they spread out as they move away from the charges. The field lines curve towards the negative charge, representing the direction of the force on a positive test charge placed in the field.

Identical Point Charges: When two identical point charges are present, such as two positive charges or two negative charges, the field lines form a symmetrical pattern between the charges. The field lines originate from one charge and terminate on the other charge. The number of field lines originating from each charge is the same, reflecting their equal magnitudes. The field lines are equidistant and spread out uniformly between the charges, forming a pattern that resembles two cones connected at their bases. The field lines curve away from each charge, indicating the repulsive force between them.

In both cases, the field lines provide a visual representation of the electric field and its direction. The density of the field lines represents the strength of the electric field, with denser lines indicating a stronger field. The field lines allow us to understand the interaction between the charges and the forces experienced by other charges placed in the field. Here's how the field lines are formed:

Charge Polarity: The field lines originate from positive charges and terminate on negative charges. If both charges are positive or negative, the field lines will originate from one charge and terminate on the other.

Radial Symmetry: The field lines are radially symmetric around each charge. They spread out uniformly in all directions, perpendicular to the line connecting the charges.

Field Line Density: The density of field lines represents the strength of the electric field. The closer the field lines are to each other, the stronger the electric field in that region.

Superposition: The electric field lines from individual charges superimpose to form the resultant electric field. The direction of the field lines is determined by the vector sum of the electric fields created by each charge.

Interaction: The field lines show the interaction between the charges. If the charges have the same polarity, the field lines will repel each other, while opposite charges attract each other. The field lines curve towards the opposite charge, indicating the direction of the force on a positive test charge placed in the field.

Field Line Patterns: The pattern of field lines depends on the relative magnitudes and distances between the charges. For example, if the charges have equal magnitudes, the field lines will be symmetrically distributed between them. If one charge is much larger than the other, the field lines will be predominantly influenced by the larger charge. It's important to note that the field lines provide a qualitative representation of the electric field. The actual strength and distribution of the electric field require quantitative analysis using mathematical equations, such as Coulomb's law or the principle of superposition, to calculate the electric field at specific points. By visualizing the field lines, we can gain insights into the behavior of electric fields, the interaction between charges, and the forces experienced by other charges placed in the field. This helps in understanding the fundamentals of electrostatics and analyzing the behavior of complex charge distributions.

- Electric field between capacitor plates: Students have misconceptions about the field lines between capacitor plates. The misunderstanding of this topic was corrected with the help of the two-dimensional design of a flat capacitor. By changing the distance of the capacitor plates, the material of the plates, and the charge of the plates, students will see the change in the shape of the field. The output of this simulation was the electric field between the plates of this capacitor is shown in Figure 3. In the case of a parallel plate capacitor, which consists of two flat plates with opposite charges, the electric field lines originate from the positively charged plate and terminate on the negatively charged plate. Between the plates of a parallel plate capacitor, the electric field is uniform and constant in magnitude. This means that the field lines are evenly spaced and parallel to each other. Figure 5 Image of field lines caused by flat capacitor plates in the surrounding space. The field lines are perpendicular to the plates and are uniformly spaced between them. They extend from the positive plate towards the negative plate. Near the edges of the plates, the field lines curve outward from the positive plate and inward towards the negative plate. These curved field lines indicate a non-uniform electric field in this region.

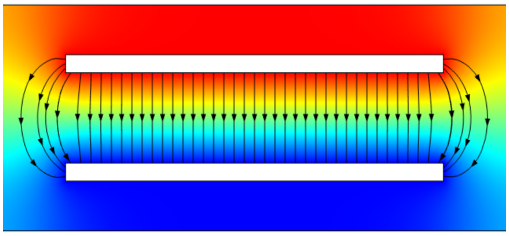


Fig. 3: Showing electric field lines between capacitor plates

Outside the plates, the electric field is negligible or zero. This implies that there are no field lines extending beyond the edges of the plates. The visualization of field lines helps us understand the electric field pattern and strength in the surrounding space of a parallel plate capacitor. It provides a useful representation to analyze and predict the behavior of electric fields in such systems. The shape and dimensions of the capacitor plates can affect the electric field lines. For example, if the plates are not perfectly parallel, the field lines may curve or exhibit uneven spacing. Similarly, if the plates are not large compared to their separation distance, there may be more pronounced edge effects and non-uniform electric field behavior near the edges. The shape and dimensions of the capacitor plates can affect the electric field lines. For example, if the plates are not perfectly parallel, the field lines may curve or exhibit uneven spacing. Similarly, if the plates are not large compared to their separation distance, there may be more pronounced edge effects and non-uniform electric field behavior near the edges. The orientation of the capacitor plates can also influence the electric field lines. In a horizontally oriented capacitor, the field lines are vertical and perpendicular to the plates. In a vertically oriented capacitor, the field lines are horizontal and parallel to the plates. When a dielectric material is inserted between the capacitor plates, it affects the electric field lines. Dielectrics have a relative permittivity (ε_r) greater than 1, which reduces the electric field strength between the plates. The field lines become more closely spaced, indicating a stronger electric field compared to the same capacitor without a dielectric. In real-world capacitors, especially with non-ideal plate shapes or finite dimensions, fringing fields may occur. Fringing fields refer to the electric field that extends beyond the edges of the plates. These fringing fields can cause the field lines to curve and deviate from the ideal straight lines between the plates. Understanding the electric field lines and their characteristics helps in analyzing the behavior of parallel plate capacitors and their interaction with other objects or charges in the surrounding space. It provides insight into the distribution and strength of the electric field, which is essential for various electrical and electronic applications.

It is important to note that the description provided here assumes an idealized scenario of perfect parallel plates and an ideal capacitor. In real-world situations, factors such as edge effects, fringing fields, and the presence of dielectric materials can affect the actual electric field pattern.

- Rotation of a charged particle placed in an external electric field: In this topic, the placement of a charged particle inside an external field applied to the particle was not conceivable for the students and caused misunderstanding. Students have wrong ideas about charge polarization. In order to correct the misunderstanding in this topic, a particle with a positive and negative charge was placed on each side between the plates of the flat capacitor. The output of this simulation is the moving force on the particle, which shows the rotation of the particle according to the figure below.

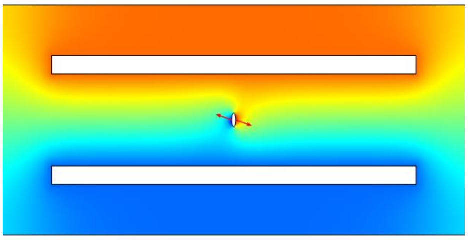


Fig. 4: Torque on an Electric Dipole in a Uniform Electric Field of capacitor

Fig. 4 Image of the tendency to change the location of the particle in the field caused by the capacitor plates. As can be seen in the figure, the part of the object that has a negative electric charge is inclined towards the capacitor plate that has a positive charge and vice versa. When an electric dipole is placed in a uniform electric field, a torque is exerted on the dipole. The magnitude of this torque is given by the formula $\tau = pE\sin\theta$, where τ is the torque, p is the magnitude of the electric dipole moment, E is the magnitude of the electric field, and θ is the angle between the dipole moment vector and the electric field vector. This torque tends to align the dipole moment vector with the electric field vector. In the case of a capacitor, if the electric field is uniform between the plates, then an electric dipole placed in this field will experience a torque that tends to align its dipole moment with the direction of the electric field. It's important to note that the behavior of a charged particle inside a capacitor can be complex and dependent on various factors, including the strength and uniformity of the electric field, the charge and mass of the particle, and any external forces or influences present. Detailed analysis and simulations may be required to accurately predict the particle's trajectory and behavior inside the capacitor.

- Load distribution in pointed objects: In this topic, the idea of accumulation of loads in sharp points and corners of shapes has created misunderstanding for students. The results of the pre-test showed that some students mistakenly think that the load distribution depends only on the transfer agent or that the loads are uniformly distributed on the surface of the object.

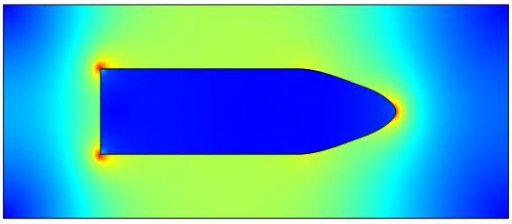


Fig. 5: Electric charge distribution in pointed objects

Fig. 5 shows how the electric charge is distributed in objects. The charge distribution on an object is influenced by several factors. The charge distribution in pointed objects is influenced by their shape and the electric field in their vicinity. When a pointed object, such as a sharp conductor, is exposed to an electric field, several phenomena come into play. Here are some key factors that determine the charge distribution and can be shown in the simulation, as follows:

Electric Field Concentration: The sharp or pointed feature of the object leads to a higher concentration of electric field lines in that region. According to Gauss's law, the electric field is stronger in areas with high curvature. This concentration of electric field lines can result in a higher charge density in the pointed portion of the object.

Charge Accumulation: Due to the concentration of the electric field, charged particles tend to accumulate on the pointed surface. If the object is made of a conductive material, such as a metal, the excess charges can freely move within the object and redistribute themselves. This redistribution leads to a higher charge density on the pointed region.

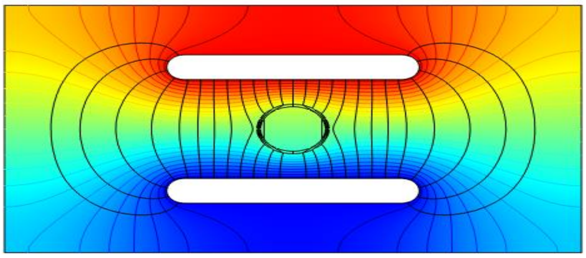
Ionization and Discharge: In certain conditions, the electric field at the pointed surface can become strong enough to ionize surrounding air molecules. This ionization can create a conductive path between the object and the surrounding air, allowing charges to flow in the form of a corona discharge. The corona discharge can further enhance the charge accumulation on the pointed surface.

The purpose of these phenomena is to reduce the electric field strength at the pointed region. By accumulating charges on the pointed surface, the object can effectively disperse the electric field, reducing the likelihood of electrical breakdown or sparking. This is why pointed objects are often used in applications such as lightning rods or sharp conductors on high-voltage equipment.

It is important to note that the charge distribution on pointed objects can vary depending on factors such as the material properties, the sharpness of the point, and the strength of the electric field applied. Additionally, the presence of nearby objects or conductors can also influence the charge distribution on the pointed object through induction or electrostatic interactions.

- Effect of external electric field on conductive and non-conductive shells: In this topic, the concept of changes in the direction of electric field lines when encountering conductive and non-conductive shells has been difficult for students to understand, leading to confusion. Analysis of the results showed that some students did not understand the changes in the electric field when it passes through conductive and non-conductive objects. They mistakenly believed that the magnitude of the electric field determines its ability to pass through objects. To address this issue, a parallel plate capacitor was simulated to create an external electric field, and then in two stages, a spherical shell made of gold (conductive) and a spherical shell made of glass (non-conductive) were placed between the capacitor plates. The output of this simulation demonstrated the changes in the electric field lines when passing through conductive and non-conductive shells. This can help students better understand how the external electric field affects the behavior of conductive and non-conductive shells. Fig. 6 shows the field lines resulting from the flat capacitor plates passing through the spherical shell a) conductive b) non-conductive. As can be seen, the electric field passes through the non-conductive shell, but does not pass through the conductive spherical shell, without changing the original algorithm with a slight deviation in the location of the shell.

When an external electric field is applied to a conductive spherical shell, such as one made of gold, the electric field lines pass through the shell and distribute the charge uniformly on its outer surface. This is known as the Faraday cage effect. Due to the high conductivity of the metal, the charges redistribute themselves to neutralize the electric field inside the shell. Consequently, the electric field inside a conductive spherical shell is zero, and the charges reside solely on the outer surface.



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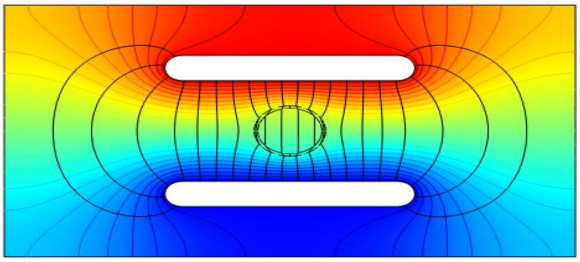

(b)

Fig. 6: Passage of the field through spherical shells of, (a) gold (conductive) and (b) glass (non-conductive)

In the case of a non-conductive (insulating) spherical shell, such as one made of glass, the behavior is different. Since insulators do not allow the free movement of charges, the electric field lines cannot pass through the shell. Instead, they terminate on the surface of the shell. This causes a non-uniform charge distribution on the outer surface of the shell, with a higher charge density at regions of higher curvature. The reason for the non-uniform charge distribution on the outer surface of an insulating spherical shell is due to the polarization of the material. Within the insulator, the electric field induces a separation of charges, with positive charges attracted towards the side facing the external field and negative charges repelled towards the opposite side. This polarization effect creates an internal electric field that counteracts the external electric field, resulting in a lower net electric field inside the insulating shell compared to the external field. In summary, for a conductive spherical shell, the charge distributes uniformly on the outer surface, with no electric field inside the shell. For a non-conductive spherical shell, the charges accumulate on the outer surface, and the electric field inside the shell is not completely canceled by the charges, resulting in a non-zero internal electric field. It's important to note that the behavior described here assumes idealized spherical shells and simplified conditions. In real-world scenarios, factors such as imperfections in the shells, surface roughness, and the presence of other objects can affect the charge distribution and electric field behavior.

Results and Findings

In this study, there were 60 male students from the eleventh grade, with 30 students assigned to the control group and 30 students assigned to the experimental group. The findings of the present research are presented in two sections: qualitative and quantitative. By incorporating both qualitative and quantitative findings, the research provides a comprehensive understanding of the research topic, allowing for a more robust and nuanced interpretation of the results.

Qualitative findings

The pattern extracted from interviews for misunderstanding categories is shown in Fig. 7. The results of the interviews indicated that the components of misunderstanding were as follows:

Coulomb's Law: Participants had difficulty understanding and applying the principles of Coulomb's Law, which describes the interaction between charged particles.

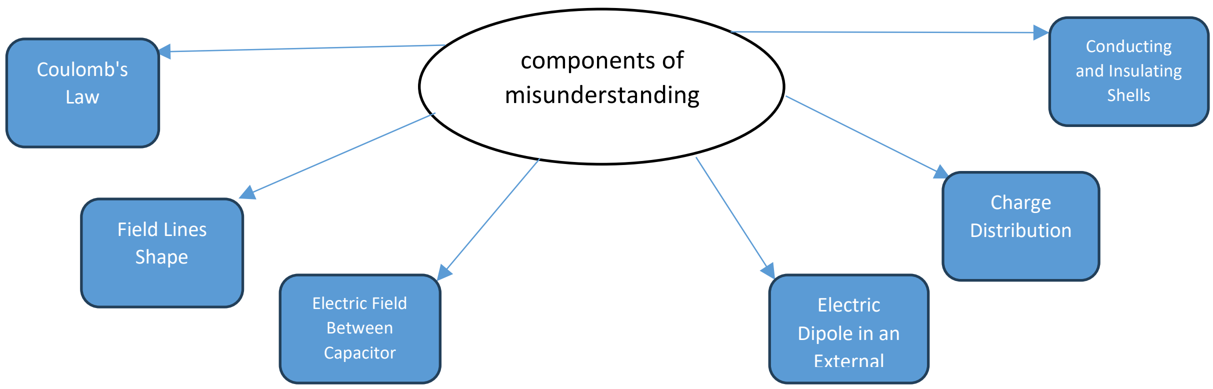

Fig. 7: The pattern extracted from interviews for misunderstanding categories.

Field Lines Shape: Some participants struggled to comprehend the concept of field lines and the shape they take around charged objects, leading to misunderstandings.

Electric Field Between Capacitor Plates: Participants faced challenges in understanding the electric field between the plates of a capacitor, including its direction and magnitude.

Rotation of an Electric Dipole in an External Electric Field: Some participants had difficulties grasping the concept of a charged particle's rotation when placed within an external electric field.

Charge Distribution on Pointed Objects: Participants had trouble understanding the distribution of charges on pointed objects, particularly how the charges accumulate or redistribute.

Effect of External Electric Field on Conducting and Insulating Shells: Understanding the impact of an external electric field on conducting and insulating shells posed difficulties for some participants.

Quantitative findings

The quantitative findings are presented in two sections: descriptive and inferential findings.

Descriptive findings

After collecting the pre-test papers in two classes and correcting them, the results were observed in Fig. 8.

After the end of the training sessions, two groups of 30 students from the 11th grade participated in the test again. The post-test results of both groups were observed in Fig. 9. According to in Fig. 10, the minimum percentage of correction of misunderstandings in the experimental group was 46.66%, while in the control group, it was 36.66%.

Using simulation-based modeling with software like COMSOL can have a positive impact on correcting misconceptions about concepts in electrical physics. Fig. 8 is shown the effects of this instructional approach on rectifying misconceptions. Utilizing simulation software like COMSOL helps students gain a better understanding of electrical physics concepts by visualizing them. After examining the correct answers of the experimental group in two tests and comparing them with the results of the control group, it can be seen that the effect of teaching with the help of simulation software in increasing the correct answers of students is far more than teaching with the traditional method. As can be seen in Fig. 10, the number of correct answers has increased significantly in the post-test phase. Descriptive findings are shown in Table 2. According to Table 2.

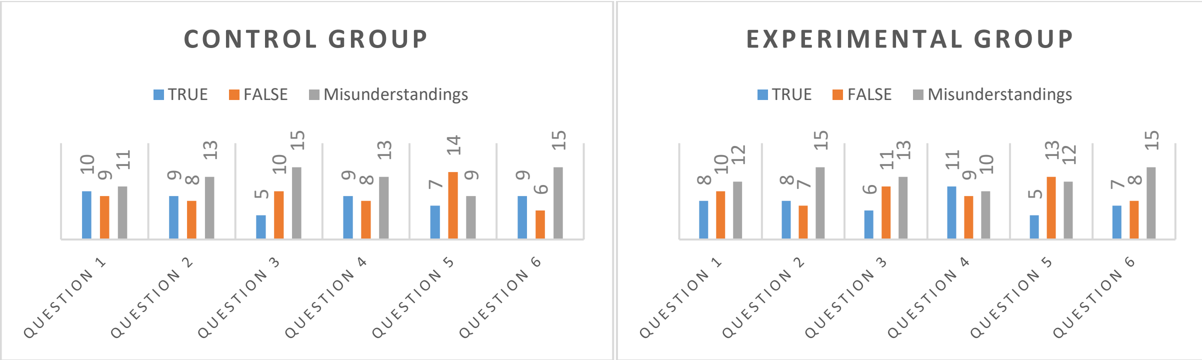

Fig. 8: The pre-test results of the experimental and control groups

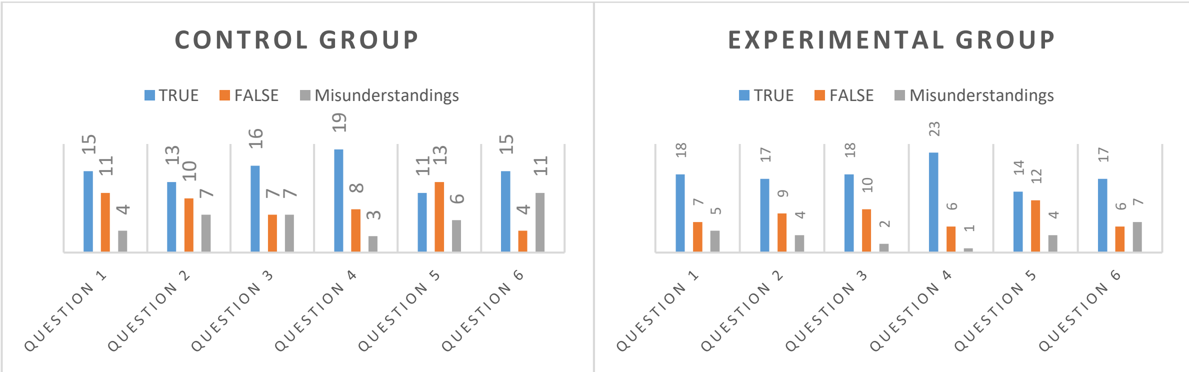

Fig. 9: The post-test results of the experimental and control groups

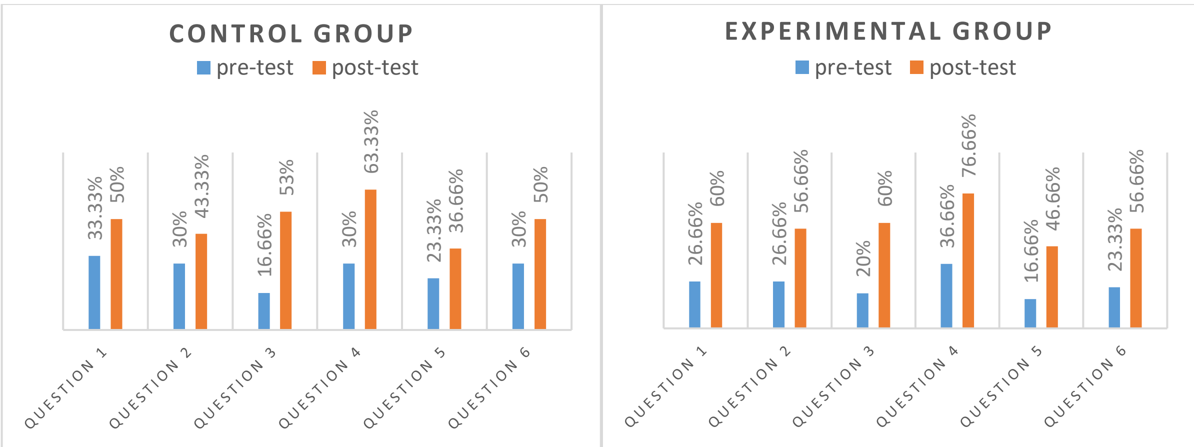

Fig. 10: Comparison of the correct answers of a sample of 30 people in two tests post-test and pre-test

Table 2: Descriptive statistics of research variables

Categories of misunderstandings of electrical physics concepts	Group	Pre-test	post-test
Coulomb's Law	control group	11	4
	experimental group	12	5
Field Lines shape	control group	13	7
	experimental group	15	4
Electric Field Between Capacitor Plates	control group	15	7
	experimental group	13	2
	control group	13	3

Categories of misunderstandings of electrical physics concepts	Group	Pre-test	post-test
Electric Dipole in an External	experimental group	10	1
Charge Distribution	control group	14	6
	experimental group	12	4
Conducting and Insulating Shells	control group	15	11
	experimental group	15	7

In the category of Coulomb's Law, initially, 11 students from the control group and 12 students from the experimental group had a conceptual misunderstanding. After the training sessions, the number of students with misunderstandings decreased to 4 in the control group and 5 in the experimental group.

In the category of Field Line Shape, initially, 13 students from the control group and 15 students from the experimental group had a conceptual misunderstanding. After the training sessions, the number of students with misunderstandings decreased to 7 in the control group and 4 in the experimental group.

In the category of Electric Field Between Capacitor Plates, initially, 15 students from the control group and 13 students from the experimental group had a conceptual misunderstanding. After the training sessions, the number of students with misunderstandings decreased to 7 in the control group and 2 in the experimental group. In the category of Electric Dipole in an External, initially, 13 students from the control group and 10 students from the experimental group had a conceptual misunderstanding. After the training sessions, the number of students with misunderstandings decreased to 3 in the control group and 1 in the experimental group.

In the category of Charge Distribution, initially, 14 students from the control group and 12 students from the experimental group had a conceptual misunderstanding. After the training sessions, the number of students with misunderstandings decreased to 6 in the control group and 4 in the experimental group. These findings indicate that the training sessions were effective in reducing conceptual misunderstandings in various categories for both the control and experimental groups.

Inferential findings

Based on the information provided in Table 3, the mean and standard deviation of post-test misconception scores for the experimental and control groups are as follows:

Experimental Group:
- Mean of post-test misconception scores: 0.1278
- The standard deviation of post-test misconception scores: 0.0712

Control Group:
- Mean of post-test misconception scores: 0.211
- The standard deviation of post-test misconception scores: 0.0935

Table 3. Mean and Standard Deviation of Post-Test Scores for Control and Experimental Groups

	Misconception pre-test		Misconception post-test	
Group	Control group	Experimental group	Control group	Experimental group
Mean	0.3	0.3056	0.211	0.1278
SD	0.0935	0.0712	0.1428	0.1369

These statistics provide insights into the average level of misconceptions and the variability of scores within each group. The experimental group, which received the simulation-based teaching method, had a higher mean score in the pre-test (0.3056) compared to the control group (0.3). However, in the post-test, the experimental group demonstrated a lower mean score (0.1278) compared to the control group (0.211), indicating a greater reduction in misconceptions among the experimental group. Moreover, the standard deviation of post-test misconception scores in the experimental group (0.0712) is smaller than that of the control group (0.0935), suggesting less variability in scores among the experimental group. These findings suggest that the simulation-based teaching method may have superiority over the traditional method in terms of reducing misconceptions and improving understanding of electrical physics concepts. The results of this variance analysis are summarized in Table 4.

Table 4: **Summary of variance analysis to investigate the effect of teaching methods (traditional and teaching using COMSOL simulation software) to correct misunderstandings of electrical physics**.

Sources Change	SS	df	MS	F	sig
Teaching methods	3.66	1	3.76	4.95	0.030
error	42.18	57	0.74		

The results of the analysis of variance (ANOVA) indicate that there is a significant difference in the effectiveness of different teaching methods (traditional and simulation-based using CAMSOL software) in correcting misunderstandings in electrical physics concepts ($F=4.95$, $P<0.05$). Furthermore, the mean score of the experimental group (0.76) is significantly lower than the mean score of the control group (1.26). Additionally, the mean score of the experimental group in the post-test (0.76) is significantly lower than the mean score of the experimental group in the pre-test (3.66).

These findings suggest that the simulation-based teaching method using CAMSOL software is more effective in correcting misunderstandings in electrical physics concepts compared to the traditional teaching method. The experimental group exhibited a significant improvement in understanding after the intervention, as indicated by the higher post-test mean score compared to the pre-test mean score.

Discussion

This research was conducted with the aim of investigating and correcting the misunderstandings of 11th-grade high school students in learning the concepts of electricity. The study utilized a mixed-methods approach. The qualitative section employed content analysis through semi-structured interviews to identify misconceptions, while the quantitative section employed a quasi-experimental design with a pretest-posttest and a control group.

The findings of this study provide valuable insights into the effectiveness of using COMSOL simulation software in correcting misconceptions and enhancing students' understanding of electricity concepts. The qualitative analysis identified several categories of misconceptions that students commonly held in electrical physics. These included misconceptions related to Coulomb's Law, field line shape, electric field between capacitor plates, rotation of an electric dipole in an external electric field, charge distribution on pointed objects, and the effect of external electric fields on conducting and insulating shells.

The quantitative analysis revealed positive outcomes in both the control and experimental groups. Descriptive findings indicated a decrease in the number of students with misconceptions in all categories after the training sessions. However, the experimental group, which received instruction using COMSOL simulation software, showed a greater reduction in misconceptions compared to the control group. The descriptive indices indicated improvements in understanding for both groups, but the experimental group showed more significant improvements. This suggests that the interactive and visual nature of the simulation software aided in correcting students' misunderstandings.

Inferential findings, including mean scores and standard deviations, further supported the effectiveness of the simulation-based teaching method. The experimental group had a lower mean score in the post-test compared to the control group, indicating a greater reduction in misconceptions. The standard deviation of post-test scores in the experimental group was smaller, suggesting less variability in understanding among students. The analysis of variance revealed a significant difference in the effectiveness of teaching methods in correcting misconceptions in electrical physics. The results of the analysis of variance indicate that there is a significant difference between the teaching methods (traditional and simulation-based instruction using COMSOL software) in correcting misconceptions about electricity concepts in physics ($F=4.95$, $P<0.05$).

Overall, the combination of qualitative and quantitative findings provided a comprehensive understanding of the topic and supported the efficacy of the simulation-based teaching approach. The findings of the study also demonstrated the simulation-based teaching method using COMSOL software was found to be more effective than the traditional teaching method. The experimental group demonstrated a significant improvement in understanding. These software tools present concepts in a visual and interactive manner, demonstrating how physics concepts work in practical applications. This aids students in establishing a stronger connection between theoretical concepts and real-world experiences. Simulation software enables students to conduct experiments and explore different settings and circuit configurations. This allows them to identify their own errors and gain a better understanding of the relationship between physics concepts and experimental results.

Similar studies in physics education have demonstrated the benefits of simulation-based instruction in enhancing students' conceptual understanding and promoting engagement in the learning process. The results align with the findings of studies conducted by Cunningham-Nelson et al. [22], Ramnarain et al. [32], and Jaakkola et al. [33], which highlight the positive impact of simulation-based instruction on learning outcomes in various subject areas. Comparing these findings with past literature, the use of simulation software in education has shown promise in improving learning outcomes and correcting misconceptions across various subject areas. The current study adds to this body of literature by specifically focusing on electricity concepts and highlighting the effectiveness of COMSOL simulation software in addressing misconceptions.

Conclusions

The use of COMSOL simulation software in this study effectively corrected misconceptions related to electricity concepts, resulting in a significant improvement in understanding among students. The simulation-based teaching method using COMSOL software was found to be more effective than traditional teaching methods in correcting misconceptions about electricity concepts.

The use of COMSOL simulation software in teaching electricity concepts can effectively correct misconceptions and enhance students' understanding. The interactive and visual nature of the software allows students to explore and experiment with different scenarios, facilitating a deeper understanding of the underlying concepts.

The use of simulation software, such as COMSOL, has significant implications for physics education, curriculum development, and instructional practices. Integrating simulation-based activities and experiments into teaching can provide students with interactive and engaging learning experiences, promoting deeper understanding and correcting misconceptions.

Moreover, simulation software can extend beyond the classroom and be utilized for self-directed learning and personalized instruction. Students can explore concepts at their own pace, allowing for individualized learning experiences and a better grasp of the subject matter.

The findings of this study contribute to the existing literature on simulation-based instruction, further highlighting the potential of COMSOL simulation software in addressing misconceptions and enhancing students' understanding of electricity concepts. This research provides valuable insights for educators, curriculum developers, and instructional designers, encouraging them to consider the integration of simulation software into physics education to improve learning outcomes and promote conceptual understanding.

Despite its implications and applications, the study had some limitations. The small sample size and the restriction to one high school grade limit the generalizability of the findings to a larger population. Additionally, the short duration of the instructional program is a limitation as it does not allow for an assessment of the long-term retention of knowledge and the persistence of the correction of misconceptions. The effectiveness of the simulation-based teaching method was evaluated immediately after the program, but the long-term retention of knowledge and the persistence of correction of misconceptions were not assessed.

While acknowledging the study's limitations, the results emphasize the potential of simulation-based teaching approaches in improving learning outcomes in physics education. The findings of this study can inform curriculum development and instructional practices in physics education. According to the findings of the current study, Educators and curriculum designers are recommended to incorporate simulation-based learning experiences into their curricula to address misconceptions and promote a deeper understanding of electricity concepts.

To effectively implement simulation-based teaching approaches, providing professional development programs for teachers is crucial. These programs can train teachers in utilizing simulation software, such as COMSOL, and integrating it into their instructional strategies. Equipping teachers with the necessary skills and knowledge will enable them to effectively leverage simulation software to enhance student learning outcomes.

Furthermore, the findings of this study lay the groundwork for future research. Similar studies can explore the effectiveness of simulation-based teaching approaches for other physics concepts and subjects outside of physics. Additionally, expanding the research to different grade levels and diverse student populations would provide a more comprehensive understanding of the potential benefits of simulation-based instruction.

Authors' Contribution

Guidance in the implementation of the research plan, data analysis and manuscript writing has been provided by Dr. Fatemeh Khodadadi Azadbani. Data collection was done by Mr. Javad Kamali.

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Conflicts of Interest

The authors have no conflicts of interest.

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Appendix

Diagnostic test for misconceptions about electricity physics concepts.

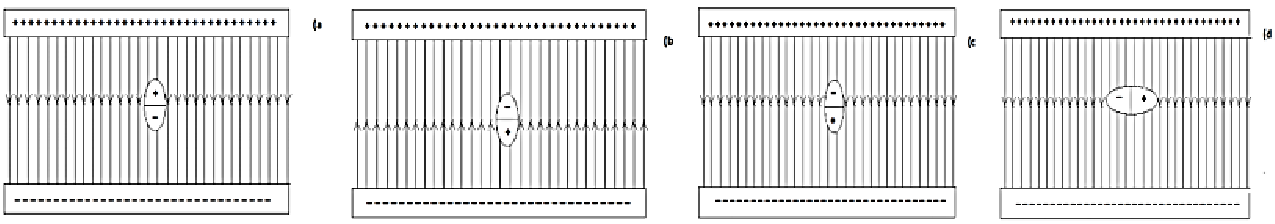
1. We place a positively charged sphere near a negatively charged sphere, what happens?
a) They approach each other.
b) move away from each other.
c) They remain fixed in place.
What is the reason for this?
a) Charges of the same name attract each other.
b) unlike charges attract each other.
c) Charges of the same name can be placed next to each other.
d) Non-identical charges do not react with each other.
Are you sure of your answer?
a) Yes
b) No

2. What is the electric field between two charged spheres?
a) From negative charge to positive charge
b) From positive charge to negative charge
c) from negative charge to negative charge
d) from adjacent positive and negative charges to the surroundings
What is the reason for this?
a) Field lines do not have a specific direction.
b) The field lines disperse with increasing distance from the charge.
c) The direction of the field lines is from the positive charge to the negative charge.
d) The direction of the field lines is from the negative charge to the positive charge.
Are you sure of your answer?
a) Yes
b) No

3. Consider a particle whose charges are polarized. An external field is applied to it by a flat capacitor, the particle is able to rotate in place, which form is true for this problem?
What is the reason for this?
a) The charged part of the particle rotates towards its homonymous charge and the direction of the field is always from positive to negative.
b) The charged part of the particle rotates towards its opposite charge and the direction of the field is always from negative to positive.
c) The particle remains motionless and the direction of the field is from positive to negative.
d) The charged part of the particle rotates towards the inhomogeneous charge and the direction of the field is always from positive to negative.
Are you sure of your answer?
a) Yes
b) No

5. Does the charge distribution in an object depend on the geometric shape of the object?
a) Yes
b) No
What is the reason for this?
a) The charge distribution depends only on the charge transfer agent.
b) The load distribution is more on the smooth sides of the object.
c) The load distribution is uniform.
d) The load distribution is more in the sharp corners of the object.
Are you sure of your answer?
c) Yes
d) No

6. How does the external electric field pass through an object, depends on the material of the object (conductor or insulation of the object)?
a) Yes
b) No
What is the reason for this?
a) Electric field passes through conducting bodies.
b) Electric field does not pass through conducting bodies.
c) Electric field passes through non-conducting objects.
d) The effect of the electric field and its penetration depends only on the intensity of the field.
Are you sure of your answer?
a) Yes
b) No



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ORIGINAL RESEARCH PAPER

The Opportunity to Up-skill Students' Verbal Representation in Design Process at Online Architecture Studios

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Verbal Representation (VR)
Language Skills

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ABSTRACT

Background and Objectives: All academic fields, including architecture, were taught online during the COVID-19 pandemic. Architectural design studios were the most challenging courses offered online among all the architectural courses. The benefits and disadvantages of teaching in online design studios have been studied through research on practitioner feedback. The current study focuses on the advantages of online studios and emphasizes the importance of verbal representation in the architectural design process. As verbal representation is utilized in the design process, with verbal description being one of its tools, the question arises: Is it feasible to enhance the verbal representation skills of architecture students, despite the limitations in content transmission and the challenges encountered during online studio delivery?

Materials and Methods: The research methodology is qualitative. It is based on a systematic literature review and case study in which authors have used an autoethnography approach, sharing their experiences as online instructors during the COVID-19 crisis. The case study was carried out via thematic analysis supported by coding employing tactics including observations, memos, self-evaluation of students, and questionnaires. The research took place at Shahid Beheshti University's Faculty of Architecture and Urban Planning for five academic semesters (2019-2022). The statistical population included 147 students (111 undergrads and 36 graduates).

Findings: The results demonstrate that, due to the constraints of material sharing compared to face-to-face studios, architectural design online studios rely primarily on listening senses and linguistic skills. The results show an improvement in students' verbal representation (both oral and written), which varies depending on the studios. In online studios, 86% of students reported that their writing ability had improved, and 73% reported that their oral representation had improved. It is worth noting that students in online studios rate verbal representation in written format as the second most improved skill out of six. As a result, the level of usage and acceptability of written and oral representation in the creative process in online studios has not been consistent, and it may alter for various reasons. Some key points that make it successful include the instructor's preference for employing verbal description and representation in the studio, the student's potential in verbal description, the theme of the design studio, and where we are in the design process.

Conclusions: Online architectural design studios provide students with the chance to improve their verbal representation skills. Additionally, one of the bases of delivering online studios is the ability to express ideas clearly via language, which also plays a compensating role during the design process in maintaining the studios' quality. Use of this feature in hybrid, online, or face-to-face studios could be part of future plans. The valuable tasks to be carried out should be defined and experienced in this context so that they can be implemented at the beginning, middle, or end of the design process. The practice of expressing the scenario, defining the design problem, writing the design statement, preparing sessions for reading descriptions from renowned authors' texts, as well as the sessions for critiquing the works of students and architects in the online studios in tutorial and judgment sessions, can be listed among them.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
54	2	6

مقاله پژوهشی

فرصت تقویت مهارت بازنمایی کلامی دانشجویان در فرآیند طراحیِ کارگاه های برخطِ معماری

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چکیده

پیشینه و اهداف: در دوران پاندمی کووید-۱۹، همه رشته ها از جمله معماری به صورت برخط تدریس شدند. در میان دروس رشته معماری، کارگاههای طراحی معماری چالش برانگیزترین دروسی بودند که به صورت برخط برگزار شدند. در طول دوران پاندمی و پس از آن، محققان حوزه آموزش معماری درباره بازخوردهای تجربه زیسته تدریس در کارگاه های طراحی معماری برخط پژوهش هایی انجام داده اند و مزایا و معایب آن را برشمرده اند. مطالعه پیش رو با تمرکز بر نقاط قوت کارگاه های برخط و توجه به اهمیت بازنمایی کلامی در فرایند طراحی معماری، سعی دارد با نظر به آنکه بازنمایی کلامی در فرآیند طراحی کاربرد دارد و توصیف کلامی یکی از ابزارهای آن است پاسخ این پرسش را بیابد : آیا با وجود محدودیت های انتقال محتوا و شرایطی که در برگزاری کارگاههای برخط داشتیم، امکان تقویت مهارت ارائه کلامی برای دانشجویان معماری فراهم شد؟

روش‌ها: روش به کار رفته، کیفی و مبتنی بر مطالعات کتابخانه ای و موردپژوهی تجربه زیسته کارگاه های برخط طراحی معماری در پاندمی کروناست. در مطالعات کتابخانه ای از مرور نظام مند استفاده شده است. در موردپژوهی از روش کیفی تحلیل مضمون به پشتوانه کدگذاری با استفاده از روش های مشاهده، یادداشت برداری، بررسی بروندادهای دانشجویان، پرسشنامه و خودارزیابی دانشجویان بهره گرفته شده است. مدت مطالعه، پنج نیمسال تحصیلی (دوران پاندمی کرونا : ۲۰۲۲-۲۰۱۹) در دانشکده معماری و شهرسازی دانشگاه شهیدبهشتی است. جامعه آماری متشکل از ۱۴۷ دانشجو است (N=۱۱۱ دانشجویان کارشناسی و N=۳۶ دانشجویان کارشناسی ارشد).

یافته‌ها: نتایج نشان می‌دهد که کارگاه های برخط طراحی معماری، به دلیل محدودیت‌های به اشتراک گذاشتن محتوا به نسبت با کارگاه های حضوری و در جبران آن، اتکای بسیار به حواس شنیداری و ظرفیت های زبانی دارند. نتایج حاکی از ارتقای توان بازنمایی کلامی (شامل شفاهی و مکتوب) دانشجویان است که بسته به شرایط هر کارگاه آموزشی میزان آن متغیر است. از نگاه ۸۶٪ از دانشجویان، توان بازنمایی کلامی آنها به صورت مکتوب در کارگاه های برخط پیشرفت داشته است و ۷۳٪ از دانشجویان مهارت بازنمایی کلامی شفاهی خود را ارتقایافته ارزیابی کردند. شایان ذکر است مهارت بازنمایی کلامی به صورت مکتوب به عنوان دومین مهارت ارتقا یافته دانشجویان از میان ۶ مهارت ارتقا یافته در کارگاه های برخط توسط دانشجویان ارزیابی شد. از دیگر نتایج آنست که سطح استفاده و مقبولیت بازنمایی های نوشتاری و گفتاری در فرآیند خلاقیت در کارگاههای برخط ثابت نبوده است و ممکن است به دلایل مختلفی تغییر کند. برخی از مولفه های توفیق این امر عبارتند از: ترجیح مدرس کارگاه برای به کارگیری مهارت بازنمایی کلامی در کارگاه، استعداد و ظرفیت بالفعل دانشجویان در توصیف کلامی، موضوع کارگاه طراحی و موقعیتی که کارگاه در فرآیند طراحی در آن قرار دارد.

نتیجه‌گیری: کارگاه های برخط طراحی معماری، امکانی برای تقویت مهارت بازنمایی کلامی دانشجویان هستند. فراتر از آن، مهارت بازنمایی کلامی، از پایه‌های برپایی کارگاه های برخطِ طراحی معماری است و نقش جبرانی در تامین کیفیت آموزشی کارگاهها به ویژه در فرایند طراحی دارد. از این ویژگی می توان استفاده کرد و در کارگاه های آینده، به صورت حضوری یا ترکیبی بهره برد. پیشنهاد بر این است تمرین هایی هدفمند در این راستا تعریف و تجربه شوند تا در مراحل آغازین و میانی و نهایی فرایند طراحی به کار گرفته شوند. از آن جمله می توان به تمرین بیان سناریو، بیان صورت مساله طراحی، نوشتن بیانیه طراحی و تدارک جلساتی برای توصیف خوانی از میان متون نویسندگان برجسته و همچنین جلسات نقد کارهای دانشجویان و آثار معماران در کارگاه طراحی معماری برخط اشاره کرد.

Introduction

Based on its nature, architectural education is a significant form of education that promotes ongoing growth. It contains a variety of courses, including theoretical, practical, studio, and internship courses, each of which has distinct features [1]. The design studios, where students test concepts, construct physical models, and present design work in a collaborative creative atmosphere, are at the center of architectural education [2]. At the beginning of the Corona pandemic, when education was required to be done online, the difficulty of running an online studio was greater than that of other classes because of its nature. At first, it seemed that the online studios were merely keeping the education alive, given the many obstacles they faced, except for the fact that they kept the health of the students under quarantine. But, despite limitations, we have seen some progress over time. Thus, the question of what strengths there are in an online architectural design studio has come to light. By becoming aware of it, one can take advantage of both if it is needed to continue with online or face-to-face studios.

To observe online design studios, noticing the design process is as base. The design process has a wide range of different perspectives and theory frameworks. Some of those views are chosen by architecture schools and implemented based on their visions and context, as well as through human resources. The issue of the representation of ideas and concepts is among the pillars of each perspective on the design process. The concept of representation can be applied in a variety of ways, for instance as evidence that architectural students have taken into account this aspect when designing their work. On the other hand, representation played an important role in this process since it was restricted by content transfer restrictions within online studios. To answer the question, this study has focused on the representations in the design process in online studios. Visual representations are usually welcomed with more energy and power, and they were previously possible in face-to-face studios, but it is hypothesized that there is a new opportunity to use verbal representations (VR) and verbal descriptions (VD) throughout the creative process in online studios.

The description serves as a tool for representation. According to Schultz, description is the expression of the relationships between things in the qualitative context of the world. He is fiercely opposed to using abstract science to comprehend and describe things in the field of education, and he believes that for architectural education, teachers must be involved in the development of the nature of things in the world [3]. Pallasmaa indicates the paradigm shift of attention to the five human senses in light of today's extreme perspective of retinal architecture. He aspires to move away from merely visual space and toward integrated human-understandable spatial dimensions. He cites Rene Spitz as saying that all perceptions originate in the mouth cavity, which acts as the primordial link between inner reception and exterior perception [4]. Antoniades enumerates several strong and valuable descriptions in architecture that have been expressed by architects even before design, and he believes that description as the basis and source of literature is one of the architect's and the instructor of intuitive architecture's inseparable tools [5].

Verbal description (VD) means a statement that represents something in words (oral or written). In specification, VD involves a full discussion of design criteria for a piece of work [6]. According to Ching, a word may encapsulate a thousand images in the mind's eye, just as an image can be more expressive than a thousand words [7]. People utilize VD to make pictures of unknown items [8]. One of the practical instances of image production is the development of a facial sketch by VD from an eyewitness [9]. Human perception verbalizes several notions in VD's imaginative architecture [10]. VD may be programmed for quality and critical element inclusion, and it can be evaluated using two parameters: target details and route information [11]. Alexander emphasized the need for description in architecture, noting that people support architects by expressing their ways of living in simple language so that they may offer living spaces for life [12]. Salingros takes into account pattern language and form language. Accordingly, each pattern language conveys distinct ways of life for various people in various fields rather is less about images and more about notions [13]. According to Adrian Forty, we have a vocabulary of words to describe the buildings that will finally take shape. He argues that the language associated with modern architecture, such as order, design, structure, and so on, is ambiguous, and that discussing architecture through words is not always intersubjective. He goes on to say that there is a distinction between "talk of" and "talk about" architecture, and that we need to talk about architecture to mean, discuss, and express ourselves [14]. Spatial forms can be stated in a variety of ways, including two-dimensional, verbal (oral or written), and mathematical; whereas functions can be defined in terms of an iconic, kinesics, or other type of system for transcribing and anthropological values that can be described verbally. [9]. According to Holl, architectural work is not viewed as a sequence of disconnected retinal images, but as a completely integrated material, embodied, and spiritual essence that comprises physical and mental structures as well as reinforced coherence and significance [4].

VD has been utilized as a literary allegory, to define characters, to represent and contextualize literary fiction, and to contextualize literary fiction during VR of architectural spaces as plot settings [11]. Another example is the experience of conception through visual and verbal presentation in an architectural design studio, where the confluence of the two is their socializing character [15]. Visual and verbal communication skills are both vital in promoting learning and evaluating graduating courses [1]. People hear verbal explanations to learn about the place in general, and the VD of the building may play an essential role in enhancing the effective navigation of people with visual impairment [16]. When designers express more complicated and abstract spatial linkages or metaphorical notions, the language of VD is affected [17]. VD aids in giving each project a more complete, deeper comprehension and reveals or uncovers areas that the numerical scores do not [18]. One aspect of VD in architecture education is dependent on the student's vision and linguistic abilities (from freshmen to graduates), another is acceptance by persuasion, a third is illuminating, and a fourth is often brief [19]. The strength of the storytelling, the degree of originality, interchangeability, enlightenment about the essence of the project, and the ability to link with design are among VDs desirable characteristics [19]. The dimensions of VD have been presented In Table 1.

Table 1: VD Dimensions hierarchy in design and criticism of case study in the studios [19]

VD Dimensions	Areas	Focused materials	Hierarchy of narrative chains	Kind of product
Reading the building	Forms, texture, color, spatial qualities, Gestalt, details	Shapes, geometry, size, structure, proportion, technical topics	Form, function, space, order	Data
Understanding the building	The essence, the lived experiences	Activities, users, context	Territories, boundaries, margins, centers, edges, paths, links	Knowledge
Understanding the concept aids in the construction	The architect's intellectual equipment, concept	Whys, existence causes	Privacy, thresholds, orientations, stance	Wisdom

Hultzsch stated the function of VD in travel writing and suggested that the ways people verbally describe buildings are inextricably tied to how they look at and make sense of them [20]. The architects, particularly the necessity for adequate abilities in public speaking, which obviously demands coherent technical writing and clear speech, evaluated the verbal technical presenting skill enhancement requirements [21]. One of the second-hand traits that resist VD is sensing, which deals with perception and spatial situatedness [22]. To establish a comprehensive and subjective grading and evaluation method, verbal grade description is advised to be employed in critique sessions in design studios [23]. Based on the importance of designer's thinking, to have an effective shared space for online studios, some experiences focus on students' feedback and discussion with instructor and peers within a critical dialogue relevant to their work through the text, source materials, images, or videos of an interview with a user [24], with some of the dialogue materials reflecting VR. VD may be used at all stages of the representation process by architectural design studios. One of them is how buildings are described in language in case studies [20]. VR, which greatly contributes to design processes, may be extensively employed with supervision, and the study of it aims to uncover the beneficial influence of coordinated usage of diverse modalities on thought-development processes and provide a developmental approach to reflecting designer identity [25].

Review of the related literature

The global architectural profession has been utilizing virtual communication and virtual spaces for over 30 years, promoting global collaboration, idea exchange, and cost savings [26]. Digital tools in architecture have influenced content creation and schools, necessitating adaptation of teaching methods, focusing on studios, distance, and combined education for relevance [27]. Since 1993, distance education in architecture has been introduced [28] but due to challenges posed by studios, this alternative has been rare until the coronavirus pandemic. Therefore, most of the researches in this field belong to post-Corona. Before reviewing the post-corona literature, the pre-corona experiences are reviewed to recover the benefits of distance education in relation to verbal representation skills. One of the concerns that is being advanced in the study of online landscape architecture education is alternate communication tools such as chat, forum, and whiteboard in online mode [29]. In 2011, in a Romanian architecture school, feedback from a distance learning experience was that because students used e-mail to chat, they experienced more writing practice [30]. In 2013, the open design studio model could prepare an infrastructure to contribute to the discussion [31]. During 2015-2018, Loannou addressed some features of delivering online studios that related to language skills and communication [32-34].

A systematic review of online studios' challenges and opportunities was conducted during the COVID-19 pandemic to learn about the consequences for architectural design studios concerning VR. This study suggests three preliminary data classifications relevant to the research questions: What are the advantages of online education, particularly in design studios? What other skills are available in online studios? Are VR skills recognized as a strength in online studios?

As the theoretical aspect is complemented by research in architectural design studios, the written outputs of students are vital to support their design. In a study conducted in the United Kingdom, students found that online education allowed them to study topics in greater depth and detail and that theoretical work combined with design work was simpler to grasp [35]. Some changes were made when studios transitioned to an unprecedented online format. For example, having students assist with graphic and verbal presentations proved useful in lowering technology obstacles [36]. During COVID-19, 615 undergraduate students studying architecture at Jordanian institutions were polled about their satisfaction with online design studios. The feedback received from students was classified into four categories: learning engagement, learning autonomy, learning quality, and learning behavior. Among these aspects, the following quotations are relevant to the possibility of employing non-visual representation: I prefer to communicate my design work in the form of group or one-on-one interaction, I prefer to get feedback in the form of oral or written input, and I can clearly convey my design without the need of manual drawings or models [37].

Communication is essential in online studios, and when we have meetings with the camera on, the communication is reliant on nonverbal clues, but after the camera is turned off, our interactions are confined to verbal cues [38]. One of the techniques and platforms used in online studios for studio criticism was 'verbal critique only,' which had a lower frequency of usage than 'critique online through drawing' [39]. When architecture students in online studios comprehend the site in a design context, they are limited to audio and visual data gathered from the internet and other people, and verbal statements or writings, as well as photos, play an important role in understanding primary and secondary data rather than in-person observation [40]. Because there were no nonverbal indications in the online studios at times [41], they had to rely on verbal clues. Online architecture education has enhanced educational outcomes by allowing students to find and develop their potential [42]. The findings of measuring human capital resilience and identifying the capacities of architecture students during the pandemic demonstrate that most people were under-equipped with the essential devices, software, and skills to communicate ideas in real time [43].

One of the suggestions for online instruction is based on the concept of verbal redundancy, which states that when utilizing multimedia, auditory verbal explanations should supplement visual materials like text or graphics without being redundant [44]. According to a study of online studios in Turkey, students believe that the use of digital technologies and the opportunity for self-realization make online studios the most advantageous option for continuing education even at a distance [45]. The verbal-linguistic intelligence of students was developed throughout the COVID-19 pandemic, and this outcome may aid us in future alternative learning [46]. Because it was impossible to point specifically to anything on the screen while using digital media in online studios, it was required to communicate verbally to transmit any pertinent information [47]. The activity of listening in, which has been seen during online studios as lurking and valid peripheral learning, has been detected in the design studios. These findings show that informal activities help students and overtly active forms of contact in remote learning [48]. Table 2 shows a summary of the references based on the literature review.

Table 2: The Related Previous Studies

Rows	Reference numbers/ The institution where the online studio was studied	Year	Methods	The findings about the capacity of online studios regarding VR
1	[29] Anhalt University of Applied Sciences, Bernburg and Dessau campuses, Germany	2005	Graduate Programs in Landscape Architecture • Focus on new technology applications. • Monitoring the processes.	Chat is one of the alternate communication tools.
2	[30] Spiru Haret University, Bucharest, Romania	2011	By placing students in the virtual education situation, they monitored the challenges that arose.	Using e-mail to chat, expiring to more writing practice
3	[31] Open University, UK	2013	They questioned if we can create an effective shared space online, and does it scale. They had about 500 students to reach the answer per presentation of the course 'Design thinking: creativity for the 21st century'.	Contribute to discussion
4	[33] School of Architecture of the National Technical University of Athens	2015	They described an experimental configuration of multiple learning environments in diverse mediums for an undergraduate design studio	Exploring Studio Boundaries • Creating a collaborative environment. •Facilitating communication and knowledge exchange.
5	[32] National Technical University of Athens	2017	Monitoring a Blended Course in Architectural Education • Utilizes online and in-class synergy. • Focuses on connectivism model. • Course content redesigned for the new medium. • Encourages student contributions to content. Course Data Analysis: • High participation, exchange, and student satisfaction post-course completion.	Outcomes: • Verbal and visual representations of student endeavors. • Vocabulary of Terminology used as a navigation tool.
6	[34] School of Architecture of the National Technical University of Athens (NTUA)	2018	Impact of New Studio Layout on Students • Analytics, blog statistics, and survey results reveal student involvement in blending. • Blending initially set by tutors, students chose their involvement level.	Studio's Blended Model Expansion • Promoted student connectivity through network-structured communication. • Adopted online modalities and reconsidered f2f meetings. • Redesigned studio as a whole. • Students' involvement in the layout's features is crucial.
7	[46] University Pendidikan, Indonesia	2020	Student Intelligence Development Post-COVID-19 • Examines visual-spatial and verbal-linguistic intelligences. • Investigating supports future learning alternatives.	Mind Map Learning: Enhances Spatial-Visual and Linguistic Intelligence •Connects to images, colors, words.
8	[41] Indian institutions offering undergraduate architecture programs	2020	Online Survey for Educator Data Collection • Gathered structured information on the transition process, and IT/online platforms/tools. • Assessed efficacy of online teaching-learning. • Tracked trajectory of blended learning.	The results convey the need for more engagement with digital tools and representational software on integrated platforms.

Rows	Reference numbers/ The institution where the online studio was studied	Year	Methods	The findings about the capacity of online studios regarding VR
9	[36] Department of Architectural Science, Ryerson University, Canada	2021	• Review of virtual teaching experiences. •Examination of scenarios, surveys, and online studio adaptations.	Teaching Modifications Enhance Student Engagement • Use of graphic and verbal presentations. •Lowers technology obstacles.
10	[37] Jordan universities	2021	615 undergraduate students studying architecture in Jordanian universities were recruited to explore the factors that constituted and affected their perceptions of online design studios.	Online Design Studio Challenges • Potential for non-visual representation. • Offers opportunities for improved user experience.
11	[40] Muhammadiyah University, Jakarta, Indonesia	2021	Study on Architecture Design Students' Site Understanding • Assesses students' comprehension of virtual and secondary data. • Measures understanding using thirteen site attributes. •Evaluates the impact of comprehension on the design process.	Architecture Students' Data Understanding • Dependence on the internet and other sources of data. • Partial understanding of site context. • Importance of verbal statements, writings, and photos.
12	[45] Bahçeşehir University, Istanbul, Turkey	2021	Qualitative Evaluation of Online Design Studio Education • Utilized qualitative approach. • Surveyed first, second, third, and fourth-grade students. •Aimed to understand opinions on online design studio education.	Results show that students think in online studios, they are given a chance to realize themselves.
13	[47] Two parallel programs in Turkey and the UK: Eastern Mediterranean University and Final International University	2021	Study on Virtual Design Studio Evaluation • Examines 360 students from eight studios. • Evaluates effectiveness in learning outcomes. •Discusses evaluation process for final design projects.	Verbal communication was necessary to convey relevant information, as digital media cannot point at specific points, making the interactive critique of 3D models superior.
14	[38] Human-Centered Design, United States	2022	Trying to find the best way forward — balancing these changes and defining a “new normal”, Corgan released its report.	Effective communication is crucial in online studios, as meetings rely on nonverbal clues during camera-on times and oral cues during camera-off times.
15	[44] School of Education, University of New England, Australia/ Department of Education, Utrecht University, The Netherland	2022	"Optimizing Online Classroom Learning" • Based on educational psychology research. • Generalizable across age groups and learning areas. • Bridges cognitive load theory and self-regulated learning research.	Online Instruction Suggestions: Verbal Redundancy • Use auditory verbal explanations to supplement visual materials. • Avoid redundant explanations.
16	[42] Hasan Kalyoncu University, Turkey	2022	Pandemic's Impact on AE • Systematic literature review and bibliometric analyses combined. • Extracted relevant documents from (WoS) database. • Explored bibliometric connections between AE and COVID-19. •Conducted content analysis.	Online architecture education has enhanced educational outcomes by allowing students to find and develop their potential.
17	[43] College of Architecture, University of Santo Tomas, Manila, Philippines	2023	They aimed to measure human capital resilience and identify the capacities of architecture students during the pandemic.	Most people were under-equipped with the essential devices, software, and skills to communicate ideas in real time.

Rows	Reference numbers/ The institution where the online studio was studied	Year	Methods	The findings about the capacity of online studios regarding VR
18	[35] School of Architecture and the Built Environment, University of Lincoln, UK	2023	• Examines the effects of blended online learning and COVID-19 on students' writing outcomes. • Compares final written submissions of two-year groups (2019-2020 vs. 2020-2021). •Uses qualitative and quantitative analyses: grades, image, reference, and NVivo word count analyses.	The outcome differs for first-year and fourth-year students. Four-year students could study topics in more depth and detail thanks to online education, and theoretical work paired with design work.
19	[39] Sir Syed University of Engineering and Technology, Karachi, Pakistan	2023	Online Studio Pedagogy in Pakistan: Analysis and Feedback • Analyzed webinars, documentation, and interviews. • Collects student feedback on online or physical studio. • Uses SPSS to correlate variables.	Online Studio Criticism Techniques • Verbal critique only. •Utilizes various platforms.

According to the literature summarized in Table 2, the methods used are classified into three categories: qualitative, quantitative, and mixed, with the percentages of qualitative and mixed being higher than quantitative. They all reviewed the relevant literature, and some did it systematically. Most of them had hands-on experiences at the institutions where the educational programs were delivered. In case studies, data collection includes monitoring, coding behaviors, memos, using questionnaires to obtain feedback from instructors and students, and so on. They debated and used content analysis, statistical descriptions and charts, comparisons of two or more groups or circumstances, and interviews with architectural education audiences to assess the results. In sum up, based on the literature reviewed, online studios had four main areas where they excel that might be used to create a conceptual model: 1) Verbal redundancy; 2) The improvement of students' written work; 3) Relying on listening media; and 4) the development of certain instructors' and students' non-visual and visual skills (Fig. 1).

Method

Participants

During the research period for five academic semesters (2019-2022), 12 online studios of Shahid Beheshti University were observed. Five separate studios in both the bachelor's and master's programs offered variation in terms of studios. Some of them repeated longer than one semester. The basics of Architectural Design have been taught twice. Architectural Design 1 has been delivered three times. Architectural Design 4 has been taught once. Architectural Design 5 has been taught twice, and Final Architectural Design has been taught four times. Two architectural design studios from the master's program—studios 1 delivered twice and 2 delivered once. There were typically 12 students in each studio. The statistical population was chosen since they were students at the studios where the authors were instructors. In sum, 147 students participated in the study 111 of whom were undergraduates and 36 of whom were postgraduates. The comments of 14 colleagues in the architectural department were also used.

Fig. 1: A conceptual model of the advantages of online studios for VR

Instruments

The case study section has been carried out through thematic analysis supported by coding employing tactics such as observation, memos, student output evaluations, questionnaires, and self-assessment by students. The questionnaire with open-ended and closed-ended questions was provided via email to all of the participants who were students. The thematic grouping of questionnaire responses is typically summed up in 5 issues: 1) Concerns around the requirements for student attendance in online studios, 2) Inquiries about the thoughts of students on the complex interactions between peers and instructors in online studios, 3) Concerns regarding the studio program, procedure, end result, and assessment. 4) Concerns regarding the visual and non-visual abilities needed by students in online studios, as well as their development or lack thereof; 5) For online studios, open questions about anything they deem significant. The Likert scale has been used to ask some of the questions. During the pandemic, another tactic for obtaining codes was to contact colleagues via social media and Adobe Connect sessions.

The studied studios were delivered online through the Adobe Connect platform. The WhatsApp social network was utilized for both simultaneous and asynchronous communication during or after the sessions. Communication at the studied studios depended on multimedia ways such as whiteboarding, photograph sharing, and indicating works using architectural modeling software such as SketchUp and Revit, in addition to verbalizing experiences. There were five regions of information absorption in the present content analysis: 1) Any oral exchanges or written communications sent via social media/LMS/email by an individual or group that pertain to the interaction between instructors and students during online studios, 2) Questionnaires, 3) Any feedback of student, such as verbal or behavioral, depending on participation and active presence to absences and lack of participation, 4) The quality and quantity of the work completed by students, 5) Task characteristics that educators specify for students include quantity, quality, and form. Up to theoretical saturation, data gathering was done using the aforementioned tactics. We utilized content analyses to examine codes produced from lived experience. The measurement tools have been derived from the data collected related to the students' outcomes. This allowed comparisons to be made between the first semester and the next semester. Another criterion for comparing the outcomes of students was the start, middle, and end of each semester. In this manner, every piece of data was taken from online studios. However, because the authors had previously worked on VR in architecture education before Corona, they had a notion of the VR abilities of architecture students generally, and their prior experiences were taken into account as assumptions in this study. The studios that were conducted more than time during the Corona era provided for a more precise and close comparison of the academic results of the students.

Procedure

In the literature review, a systematic review of online studios' challenges and opportunities was conducted during the COVID-19 pandemic to learn about the consequences for architectural design studios with respect to VR. The scope of the search included scholarly journal articles, and the publication period was limited to 2019 to 2023, based on articles identified using Google Scholar, WOS, and Scopus database searches, and relevant to the keywords 'online architectural education' AND 'opportunities' AND 'Covid-19'. Alternative spellings, synonyms, and similar phrases were used to restrict the search. Only English-language articles were included. Proceedings, book chapters, internet sources, and books were used to elaborate on the research topics and aims. Full articles were included, however, only abstracts or presentations were removed. Using the search string, 117 entries were retained after filtering. After that, we searched the articles using the keywords 'online studio' AND 'skills' AND 'verbal representation' AND' verbal description', and only around 19 records remained. To extract data from primary publications, this study suggests three preliminary data classifications relevant to the research questions. All of the papers reviewed highlighted the obstacles and limits of online architectural education far more than the benefits and opportunities. Because the current study intends to continue the search among the strengths, the strengths connected to VR have been focused and analyzed.

Along with the techniques used to collect student feedback in the case study, we observed online studios in the following areas: activities/steps/creativities, knowledge, procedures/methods, individuals/groups, and instruments. Each of these dimensions is investigated with an emphasis on representation. More specifically, we analyzed the quantity and quality of outcomes produced by students in connection to VR at each level of the design process. The following steps are often engaged in the architectural design process and we followed them: Preparation and preliminary processes include a) addressing the design challenge; b) programming; c) site analysis; d) case study; e) etude of alternatives; f) analysis of alternatives; g) selecting on the best alternative; and h) developing the layout. The documentation was based on a running log of student feedback throughout the semester, as well as their performance in the studio and end-of-semester submissions.

Design

The questions raised about the strengths of online architectural design studios in relation to verbal representation, utilized a research design to carry out this study (Fig. 2).

The research method is qualitative with a dual basis. One side refers to a literature review that comprises an overview of VR and its tool, called VD, as well as a synopsis of the available research to highlight the major benefits of VR acquired from online studios across the pandemic. Coding was utilized to investigate and analyze data linked to the research issue in the case study where the authors demonstrated their experiences as online studio facilitators using an autoethnographic strategy. Based on the literature review, a conceptual model with four characteristics for online studios' strengths concerning VR was developed. The lived experience built into some more aspects of the situation. The findings of those two actions, as well as discussions about the findings, guided the research to its conclusion.

Results and Findings

Tables 3 and 4 display the questionnaire responses. Table 3 lists some codes that deal with circumstances where applying VD more often than usual was necessary. especially in the tutorial and discussion phases of the design process.

Table 4 shows the students' perceptions of their skills. "What was the level of the student's skills at the end of a certain online studio?" in response to another question comparing their skill level to earlier, they stated that six of their nine skills have significantly improved. 3D modeling (96%), drawing (92%), writing the documents (86%), sketching (75%), oral presentation and verbal description (73%), and participation in group communication (57%). Their three skills, however, had deteriorated: Making maquettes (63%), hand sketching (60%), and giving comments in the studio/extracurricular (48%). In comparison to the previous skills, no one addressed the following: 3D modeling, document drawing, hand drawing, and sketching. 10% of the participants rated their VD skills as poor. 9% said they were bad at hand drawing and 13% thought they were weak at producing maquettes. This is despite the fact that in skills such as 3D modeling, providing feedback to the studio on the training, and drafting papers, nobody gave her/him a zero grade.

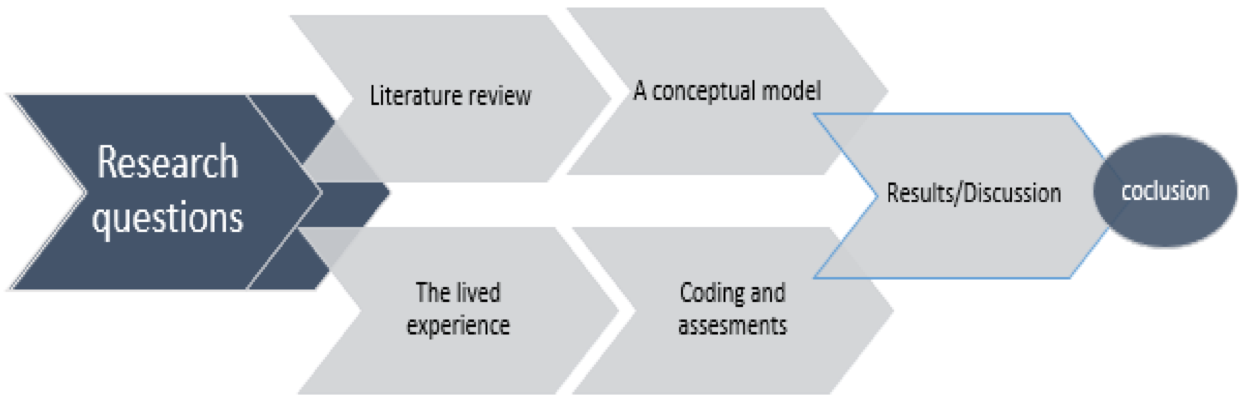


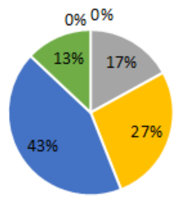
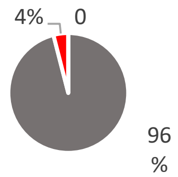
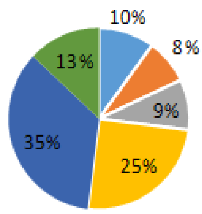
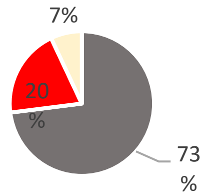
Fig. 2: Research design

Table 5 shows the views of the architecture department's colleagues. Based on the content of Table 5, several VR-related codes and phrases have been retrieved. Some elements include, for example, recognizing the relevance of VR in online studios, recovering VD as a vital content transfer technique for online studios, and emphasizing the need to generate practice circumstances in online studios to enhance VR.

Table 3: Example statements from participants on VR skills in online studios

Rows	Students' quotes	Codes related to the VD
1	Before Corona, we used to draw first, and if my sketching was poor, I would provide explanations and utilize class objects, models, and hand gestures until I could address the ideas and concepts. Unfortunately, doing so proved tough in the online studios. However, every one of us strives to compensate for this deficit. For instance, we increase the number of drawings. For 3D rendering, we largely rely on software. We also provide more in-depth verbal descriptions of our work.	More VD in online studios is required as a compensating skill.
2	We attempted to speak in a more edited manner in the online studios because the classes were recorded.	Make a revised speaking situation.
3	In the portions of the session where there were theoretical talks, I asked myself what would be added if this meeting were held in person, and I tried to fill in the gaps as much as I could. Most of the time, I didn't feel much different from the face-to-face studio, and I didn't sense the distance, and I was happy with the interchange of ideas I had with classmates.	highlighting the original position of VD and VR in-studio discussion meetings during the design process
4	The studio was recorded; it was good, and I had the opportunity to listen to the class's voice again to better comprehend the content.	Having the studios broadcast even with the voice that communicates the significance of words.
5	The most significant thing to me is that, despite their hectic schedules, some instructors let us leave notes for them in PV. It meant a lot to me that they took the time to react to our messages.	The significance of maintaining verbal contact outside of the studio

Table 4: Students' self-assessment of their competence level in online studios vs. face-to-face studios

Rows	The Skills	The level of students' skills ■ 0 ■ 1 ■ 2 ■ 3 ■ 4 ■ 5 The charts are organized using Likert scales, with grade 0 representing the least proficiency and grade 5 representing the most skill.	In comparison to the previous status ■Promoted, ■ Decreased □Unchanged
1	3D Modeling		
2	Oral Presentation and Verbal Description		

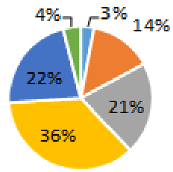
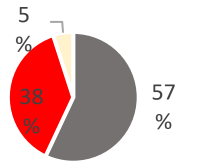
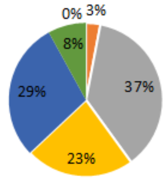
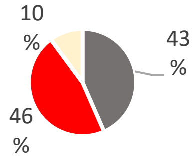
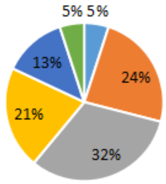
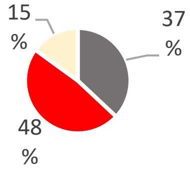
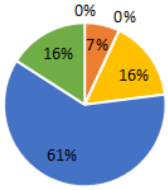
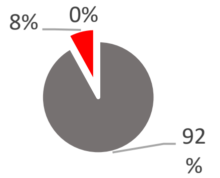
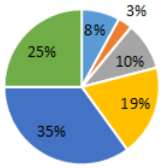
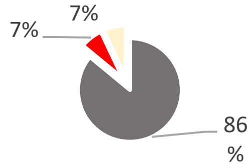
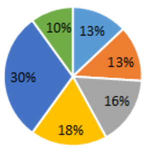
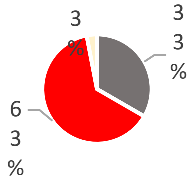
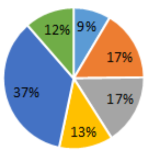
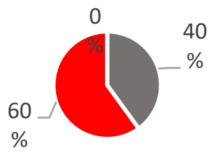
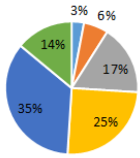
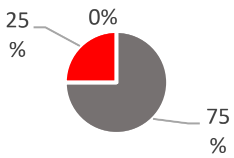
Rows	The Skills		The level of students' skills 0 1 2 3 4 5 The charts are organized using Likert scales, with grade 0 representing the least proficiency and grade 5 representing the most skill.	In comparison to the previous status Promoted, Decreased Unchanged
3	Participate in group communication			
4	Making comments in the studio	In relation to the course		
		Unrelated to the subject of the course		
5	Document creation (drawing)			
6	Creating the documentation (writing)			
7	Making a maquette			
8	Hand drawing			
9	Sketching			

Table 5: Examples of colleagues' comments on VR skills in online studios

Rows	The colleagues' quotes	Codes and Statements
1	Students' and educators' ability to implement VD has increased in comparison to before.	The significance of having VR in online studios and upskilling it
2	We have a tutorial WhatsApp group in which it is prohibited to insert a voice to practice writing better and more precisely.	Creating possibilities for practice in online studios to develop VR skills
3	When the internet was poor and we couldn't use cameras or send photographs, we relied largely on sound. As a result, in those sessions, all material was conveyed through words.	The restriction of having just sound as a form of content transmission
4	Regardless of the amount of ability of various instructors to utilize VD, they were forced to employ this material transfer way in online studios more than ever before.	VD is an important content transfer approach in online studios.
5	Essentially, issues dealing with the description of life and the representation of human experience in architecture created a place for VD to play an essential role in the design process. This issue was already present in non-online studios, but it became more palpable in online studios due to the limits of transferring concepts.	The design topic has an impact on the amount of VD used.
6	The duration of the online studios was limited in relation to the quantity of work that had to be completed, and it was necessary for students and instructors to connect with extra tutors outside of the studio. As a consequence, images, papers, and text descriptions of the items were used to share them. Therefore, writing became increasingly interwoven into the whole design process.	The importance of incorporating text into visual materials

Table 6 summarizes the author's direct involvement in developing the online architectural design studios. According to Table 6, the function of VR has influenced each step in the design process; however, certain processes have been affected more than others. Site analysis and client and user recognition, discussion for the design problem and topic, design statement and scenario, group tutorials, and written and oral presentations are the most frequently associated with VR skills. When compared to the two stages of the greatest and least usage, it appears that the amount of application of VR abilities in criticism, judgment, and evaluation is in the middle position. In general, compared to the pre-online studios' condition, online studios' reliance and demand for VR had risen to some amount.

Table 6: Examples of codes connected to VR competence in the process of creation in online studios based on authors' experience

Rows	The authors' remark	Codes and Statements	Placement in the design process
1	More than in-person studios, it was possible to accomplish tasks like reading descriptions provided by others in relation to the design themes.	Practice is important for improving our VD. It's helpful to write the design statement. It is helpful to express the design topic's core ideas. Expressing recollections and firsthand experiences from locations relevant to the project's theme might be beneficial.	- Case studies criticizing - Site analysis - Spatial programming - Knowing your users - Presentations - Discussion - Expressing design statement

Rows	The authors' remark	Codes and Statements	Placement in the design process
2	The students did a good job of using words and writing to convey the scenario, and generally speaking in the online studios, it appeared that the students relied more on words in the initial sessions. Nevertheless, several of them chose the form vocally before sharing the non-verbal version with the class.	In the studio's initial sessions, the verbal presentation took precedence over the visual display.	- Writing the scenario - A description of the forms that are utilized
3	The students' expressive techniques differed from one another, and this was one of the interventions. On the other hand, each student's hand sketching strength varies.	Different levels of VD and hand drawing skills should be evaluated because they are complementary.	- Rhetoric situation [49] - Judgment - Saturation in design decisions - Etudes - Alternative generating
4	Due to the limits of online studios, to keep the studio dynamic and to avoid becoming boring, and the majority of the students could participate, the tutorials were held jointly most of the time.	In non-individual tutorials, after analyzing an example of the student's work, instructors gave generalizable suggestions for all students in the form of vocal descriptions in collaboration with the students.	- Non-individual tutorials - Providing advice, avoidances, and design guidelines
5	Due to the need of continual assessment in online studios, delivery continuity occurred multiple times throughout the semester. As a result, the students' recording of the procedure rose.	As some tasks had to be self-explanatory with the option of verbal explanations, the quality and quantity of the outputs were critical.	- The procedure - Continuous evaluation - The product - Presentation - Delivery - Assessment
6	The use of VD proved effective for the design problem. For example, in dialogue about 'housing design,' professors, students, and even studio guests had a greater need for VD.	The progress of some design problems is more closely tied to VR skills.	- design problem solving - design scenario - programming - design development
7	Site analysis, customer demands, and user requirements were all confined to communication via the virtual platform.	Online interviews with clients or users necessitated the application of linguistic skills. During site visits, students presented their findings visually and vocally to their classmates.	- visiting the site - visiting the cases - meeting with the client/the users - site analysis
8	Individual tutorials via e-mail or social media, as well as the number of words related to photos to explain them, have surged in popularity among students.	Individual design process evolution necessitated the distribution of a piece of explicating text completing the images.	- Individual tutorials - Developing design

Discussion

Based on Fig. 1, the conceptual model collected from the systematic review, four areas were stated as strengths of online studios in connection to VR skills. Three areas in the conceptual model are also proven in the actual lived experience. However, in the case of the fourth category, which is about upskilling VR of students and professors, the current research could only focus on students and did not explore instructors' skills. As a consequence, the results are consistent with the literature solely in the aspect of enhancing students' VR skills. In the current study's lived experience, it was discovered that by depending more on voice, modifying speech, and attempting to overcome the constraints of online studios, the possibilities afforded by VR skills were employed more. Another requirement in online studios that had a direct influence on the advancement of VR was the necessity to write down comments and assignments. They highlighted the focus on more edited writing and even enhanced students' writing abilities. The exchange of viewpoints was done on social networks as a supplement to the studio, and the students were forced not to share their voices and write their comments, these experiences also helped to enhance their writing.

As stated in the results section, there was a need for verbal presentation and representation skills throughout the design process: in some early stages such as scenario statement, site analysis, and programming, in the middle stages such as ideation and generating alternatives, and in the final stages such as discussing and judging the works. As a consequence, in response to the current research question, one of the most notable triumphs of online studios was the development of VR skills, due to the constraints of using photographs, three-dimensional volumes, and the limitation of employing body language. Students' VR abilities increased when compared to face-to-face training, both verbally and in writing. According to the research findings in the self-evaluation section, the improvement in writing was somewhat more than in vocal expression. However, this result is debatable, and more research is needed to determine this issue.

Essentially, online education is challenging during the pandemic, and it is even more difficult in some disciplines that are not word-based and are dependent on experience and skills [50]. It is important to recognize the architectural design studios in regard to being word-based or hands-on, according to different stages of the design process. As a result, despite the limitations of online Hands-on education, the word-base feature of the design process assisted online studios in doing the word-base portion as effectively as possible with the support of VR skills, compensating for the non-word base feature. There is no literature that contrasts with the conclusions of this article, however, there are some studies that have similarities with the current study's findings, which will be discussed below. According to Hasanuddin University in Indonesia, the usage of various communication skills in virtual space has boosted the capacities of instructors and students in numerous dimensions such as writing, performing, and visual goods [51]. The research was undertaken at certain Jordanian university architecture faculties regarding moving learning from the traditional mode to online studios as a new norm to respond to the crisis known as the Covid-19 pandemic, one of the conclusions of which is as follows: Students might obtain judgment comments and writing from the teacher regarding their work, which is highly suggested for future encounters, particularly for new students [52].

Researchers from Turkey and Spain analyzed the highlighted requirement to fulfill a platform for establishing online studios by comparing the processes of online education in the two countries. They achieved five components in their study by going via two separate schematic pathways for two colleges from the listed nations, the first of which is efficient use of language [53], which is consistent with this research conclusion. We should observe the effective use of language in practice VD in online studios so that we may focus on the substance of the studios from a different perspective. This suggestion is consistent with the study, which found that much of the existing research on online education is based on face-to-face content, is not focused on topic areas, is based on a post-secondary audience, or fails to incorporate data from instructors themselves to triangulate conclusions [54].

Conclusions

According to the article, online architectural design studios have the potential to upskill architecture students in every stage of the design process. The opportunity may be presented in both written and oral form. Furthermore, one of the foundations of providing online studios is the capacity to convey ideas properly via language, which also serves as a compensatory function during the design process in sustaining the studios' quality. This capability is critical for programming and delivering online studios. Using Verbal representation and trying to improve it creates a soft educational infrastructure that has some affordances: the possibility of using it in hybrid, online, or face-to-face studios and addressing tasks for the early, middle, or end of the design process.

Some issues about the study's practical consequences and applications might be stated: The first stage is to pay close attention to how language and words may help advance the educational process in architectural design studios, whether online or in person. In the next phases, and especially in online studios, specific assignments based on the value and efficiency of VR, both in written and oral form, must be included in the studio schedule. Some activities, such as reading descriptions of structures by notable authors, might be instructional events in online studios. To include tasks to enhance VR skills, instructors should consider what stage of the design process they are at and how much potential and opportunity each step provides for including such tasks. Because not all stages of the design process are equally open to improving VR skills. For example, in the early phases of the design process, we may specify certain duties related to the design problem, define the design scenario, the writing of the design statement and manifest, and the recounting of the lived experience from the perception of the design site. Verbal presentations of alternatives, in addition to nonverbal presentations, might be valuable in the intermediate steps of the design process. Furthermore, when referring to case studies, criticism of them is heavily reliant on VR. Finally, at the end of the design process, during the student presentations, and the jury discussions, there is a fantastic opportunity to improve VR Skills.

According to the research, the level of usage and acceptability of written and oral communication in the creative process in online studios has not been consistent, and it may alter for various reasons. Some of these successful characteristics include the instructor's preference for employing verbal description and verbal representation in the studio, the student's potential in VR, the theme of the design studio, and where we are in the design process.

There are various constraints that the authors faced when doing the research. One of the obstacles was a lack of literature on the issue as outputs of online studios at the start of the research since they had not been published and other researchers were conducting at the same time. There were a few references to distant design studios before Corona, and they needed to be more compatible with what we experienced throughout the Corona era. As a result, it was essential to rely on firsthand experience, and after some time, the option of incorporating the findings of other researchers could have been considered. In addition to this constraint, we had no prior experience with online studios before the pandemic. Among the other intervenors was the variation in a priori and a posteriori impression of online studios for different student groups and levels. Among other constraints, the emotional and physical circumstances of trainers and trainees in online studios should be considered. Another constraint is that it was not able to compare parallel face-to-face studios with the current research during the pandemic.

This study is the topic's volume zero, and it might be developed throughout time and in other faculties for different studios and students. As a result, one of the recommendations for future study is to investigate the issue in various educational environments to learn more broadly about linguistic capacities and VR skills in architectural studios, particularly online modes. In this situation, a portion of the background characteristics that aid in the development of VR abilities may be retrieved. In addition, we may leverage the current study findings in hybrid studios in its online component to gather further input from its audiences and users and use it to validate the findings. Furthermore, if we can set up a situation in which we have two categories of online and in-person studios running at the same time, we could compare the two groups in deeper studies.

Authors' Contribution

The ideas, execution, article writing, and data analysis are all the responsibility of the first author, Hossein Pourmehdi Ghaemmaghami. The writing was also worked on by the second author (corresponding), Azadeh Khaki Ghasr, who had collaborated with implementation support for the study.

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Conflict of Interest

The authors here certify that this material has not previously been published and that it is not now being considered for publication anywhere in any language. The "Iran National Science Foundation: INSF" provided funding for this study. Rethinking Paradigm Shift of Architectural Education to Online Mode in the Covid-19 Pandemic (Case Study in Architectural Courses at Shahid Beheshti University) is the name of the supported project. The project's COD number is 99009275.

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ORIGINAL RESEARCH PAPER

Examining the Impact of Ceiling Slope on Student Stress and Cognitive Performance: A Neuro-Architectural Study Utilizing VR

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ABSTRACT

Background and Objectives: The learning environment refers to different settings in which students partake in their studies or learning. In recent years, there has been a focus on implementing diverse research to analyze physical settings to improve students' performance in educational settings. The emergence of Neuro-architecture, a growing field that integrates neuroscience principles into architectural design, has gained popularity in optimizing student engagement and learning outcomes. By understanding the neural mechanisms that influence interactions with the built environment, neuro-architecture provides novel avenues for developing learning spaces that support optimal students' performance. Previous Neuro-architecture research has explored various physical aspects within educational settings, including classroom size, color palettes, lighting, acoustics, and indoor air quality, revealing their impacts on memory, attention, emotional reactions, cognitive abilities, and learning advancement. However, limited attention has been given to stress-induced arousal, as well as the influence of classroom ceiling slope on students' stress levels and cognitive abilities. This study seeks to fill this gap by examining how the classroom ceiling slope relates to students' stress levels and cognitive function. Employing Virtual Reality (VR) simulations, cognitive assessments, and physiological measures, the study aims to answer the research question: How do varying ceiling slope orientations affect physiological responses linked to stress-induced arousal and cognitive function? The findings of this study will enhance the realm of research on learning environments by providing insight into the influence of physical features, such as the slope angle of classroom ceilings, on student wellness and academic performance.

Materials and Methods: The research employed a quasi-experimental design to explore the effects of various Ceiling Slope Variations (CSV) on stress-induced arousal and cognitive performance. A total of 18 participants, comprising nine males and nine females, participated in the experiment, selected based on five inclusion criteria established to maintain study consistency and reliability. In the first phase, participants' stress levels were evaluated through the utilization of an Emotibit bio-data logger and Visual Analogue Scales (VAS) test for measuring and mapping psychological responses. This involved monitoring heart rate variability (HRV) and electrodermal activity (EDA) in the surveyed individuals, with the objective of understanding how various ceiling slope orientations affected stress levels. The subsequent phase focused on assessing participants' cognitive abilities by utilizing the N-back test, a well-established task for gauging working memory and attention. The aim was to investigate how different CSV configurations influenced cognitive performance. In the final phase, the relationship between participants' psychological and physiological responses was analyzed using the Analysis of Variance (ANOVA) test. This examination aimed to uncover the connection between stress-induced arousal and cognitive performance in relation to the diverse ceiling slope orientations.

Findings: The findings highlight the important role of ceiling slope orientation in impacting stress levels and cognitive performance among students. Specifically, the research emphasizes that a backward-sloping ceiling design, particularly in relation to the class board, is associated with enhanced cognitive abilities, including higher accuracy rates and reduced instances of incorrect answers, compared to traditional classroom layouts. Conversely, the conventional classroom design results in the lowest cognitive performance levels. Furthermore, the study indicates that variations in ceiling slope can also trigger physiological responses in students, such as changes in heart rate and skin conductance, leading to diverse stress levels. The results suggest that integrating a backward sloping ceiling design can significantly alleviate stress levels in the surveyed participants, showcasing the potential benefits of such ceilings in educational environments.

Conclusions: This research highlights the critical importance of educational space design in alleviating stress and enhancing cognitive abilities among students. Through the utilization of VR simulations and the assessment of physiological and cognitive reactions, the study offers valuable insights into how variations in ceiling slope can impact stress levels and cognitive performance. The results indicate that integrating a backward sloping ceiling design can play a significant role in reducing stress and boosting cognitive functions in students. These findings underscore the importance of developing educational environments that prioritize neuro-architectural principles to promote optimal learning outcomes and student welfare. It is imperative for educational institutions to take into account these considerations when structuring classrooms, ensuring the creation of spaces that nurture students' cognitive processes and overall well-being.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
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مقاله پژوهشی

بررسی تاثیر شیب سقف بر استرس و عملکرد شناختی دانشجویان: با رویکرد معماری عصب محور در VR

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پیشینه و اهداف: محیط یادگیری به هر گونه محیطی اطلاق می شود که فرایند یادگیری در آن اتفاق می افتد. در سال‌های اخیر، پژوهش‌های متنوعی با رویکردهای متفاوت به تجزیه و تحلیل کیفیت‌های محیط فیزیکی یادگیری به منظور بهبود و ارتقا عملکرد یادگیرندگان در محیط های یادگیری پرداخته اند. در همین راستا پیشرفت‌های شکل گرفته در رویکرد معماری عصب محور، زمینه‌ای رو به رشد که اصول علوم اعصاب را در طراحی معماری ادغام می کند، منجر به کاربست این رویکرد جدید در بهینه سازی ویژگی‌های محیط‌های یادگیری و ارتقا عملکرد یادگیرندگان شده است. تحقیقات قبلی در زمینه معماری عصب محور، ویژگی‌های فیزیکی مختلفی را در محیط‌های آموزشی، از جمله اندازه کلاس، رنگ کلاس، نورو صدا،و آسایش حرارتی در محیط‌ای یادگیری را بررسی کرده‌اند و تأثیرات آن‌ها را بر حافظه، توجه، واکنش‌های عاطفی، عملکرد شناختی و پیشرفت یادگیری آشکار کرده‌اند .با این وجود، بررسی ها نشان داد که در این پژوهش‌ها توجه محدودی به بررسی تاثیر شیب سقف کلاس بر سطح استرس و عملکردهای شناختی دانشجویان شده است. در همین راستا، هدف این پژوهش آنست که با ارزیابی‌های شناختی و عملکرد فیزیولوژیکی مخاطبان در مواجهه با کلاس درس به این سوال پاسخ دهد که چگونه جهت‌گیری‌های شیب سقف بر پاسخ‌های فیزیولوژیکی مرتبط با برانگیختگی استرس مخاطبان و همچنین عملکرد شناختی آنها تأثیر می‌گذارد؟ یافته‌های این پژوهش به حوزه معماری عصب محور کمک می‌کند و بینش جدیدی در مورد اینکه چگونه عوامل فیزیکی، به‌ویژه شیب سقف کلاس‌ها، بر سلامت روان و عملکرد شناختی یادگیرندگان تأثیر می‌گذارد، ارائه می‌کند.

روش‌ها: در این پژوهش از روش شبه آزمایشی برای بررسی تأثیر تغییرات مختلف شیب سقف بر برانگیختگی ناشی از استرس و عملکرد شناختی شرکت‌کنندگان استفاده شده است. در این راستا ۱۸ شرکت کننده، شامل ۹ دانشجوی مرد

و ۹ دانشجوی زن، در محیط واقعیت مجازی(VR) مورد آزمایش قرارگرفتند، که انتخاب آنها به صورت نمونه گیری دو مرحله ای از بین داوطلبین شرکت در آزمایش و بر اساس پنج معیار تعیین شده برای حفظ روایی و پایایی پژوهش شکل گرفت. فرایند آزمایش شامل سه گام جداگانه بود: ۱) سطح استرس شرکت‌کنندگان از طریق استفاده از حسگر فیزیولوژیکی Emotibit و آزمون مقیاس‌های آنالوگ دیداری (VAS) مورد ارزیابی قرار گرفت. این فرایند شامل ثبت تنوع ضربان قلب (HRV) و فعالیت الکترودرمال (EDA) آنها بود. ۲) با استفاده از آزمون استاندارد N-back حین تجربه مجازی فضای کلاس‌ها، به ارزیابی عملکرد شناختی شرکت‌کنندگان پرداخته شد. هدف این دو گام آن بود که بررسی شود چگونه جهت گیری های مختلف سقف بر عملکرد شناختی و سطح برانگیختگی استرس شرکت‌کنندگان تأثیر می‌گذارد.۳) رابطه بین جهت گیری های مختلف سقف و پاسخ‌های شناختی و فیزیولوژیکی شرکت‌کنندگان با استفاده از آزمون تحلیل واریانس (ANOVA) مورد تجزیه و تحلیل قرار گرفت. این بررسی با هدف تعیین ارتباط بین برانگیختگی ناشی از استرس و عملکرد شناختی در رابطه با جهت‌گیری‌های متنوع شیب سقف انجام شد.

یافته‌ها: یافته ها نشان می دهد که جهت شیب سقف، به سمت جلو و عقب کلاس درس، به طور معناداری بر سطح استرس و عملکرد شناختی شرکت کنندگان تأثیر می گذارد. طراحی سقف با شیب به سمت عقب کلاس درس، عملکرد شناختی بهتر و تعداد پاسخ های نادرست پایین تر در آزمون شناختی N-back را در مقایسه با کلاس‌های درس با سقف بدون شیب و یا با شیب سقف به سمت جلو نشان می دهد. این مطالعه همچنین نشان می‌دهد که تغییرات شیب سقف باعث ایجاد تغییراتی در پاسخ‌های فیزیولوژیکی شرکت کنندگان می‌شود.از نتایج دیتالاگر Emotibit و آزمون VAS شرکت‌کنندگان مشخص می‌گردد، کلاس با سقف شیبدار به سمت عقب کلاس می‌تواند به طور قابل‌توجهی سطح استرس را در شرکت‌کنندگان مورد بررسی کاهش دهد.

نتیجه‌گیری: این پژوهش بر نقش کلیدی کیفیت طراحی محیط‌های فیزیکی یادگیری در کاهش استرس و ارتقای عملکرد شناختی در بین یادگیرندگان تأکید می‌کند. نتایج نشان می‌دهند استفاده از طراحی سقف کلاس‌های درس با شیب به سمت عقب کلاس می‌تواند منجر به کاهش سطح استرس و ارتقا عملکرد شناختی دانشجویان شود. این پژوهش هم راستا با مطالعات معماری عصب محور پیشین در زمینه محیط‌های یادگیری، تاکید می کند که در طراحی کلاس‌های درس، طراحان آموزشی باید به کیفیت‌های فیزیکی محیط‌های یادگیری از جمله جهت شیب سقف کلاس‌ها توجه مضاعف داشته باشند تا محیط‌هایی را ایجاد کنند که فرآیندهای شناختی-احساسی-ادراکی یادگیرندگان را پشتیبانی کرده و به یادگیری، رشد، و در نهایت بهزیستی کلی دانشجویان و یادگیرندگان کمک کنند.

Introduction

The term 'learning environment' encompasses various settings and factors in which students engage in studying or learning, ultimately impacting their educational experience and outcomes. These factors include the quality of teachers, availability of classroom resources, peer relationships, and the overall school culture. Additionally, family support, socioeconomic status, and individual learning preferences play crucial roles in creating an environment conducive to learning and growth. Educators play a significant role in shaping the learning environment by considering and addressing these factors to provide optimal support for all students. The physical environment of the classroom, including elements such as lighting, temperature, and seating arrangements, also plays a key role in influencing learning outcomes. Recent research highlights the importance of various physical attributes, such as color schemes, ventilation, acoustics, thermal comfort, scenic views, class size, and layout, in enhancing student performance and engagement in educational settings.

Moreover, factors like natural and artificial lighting, as well as ergonomic furniture, have been identified as key contributors to improving student well-being and performance in school environments. By recognizing the impact of these elements on student learning, educators can create an environment that promotes successful academic achievement and overall well-being.

In recent years, various design approaches and strategies have been implemented to enhance students' performance in learning environments [1]. Neuro-architecture, as a novel approach, has shown significant progress and has expanded its influence into different architectural domains, particularly within educational settings. This innovative method has been successfully integrated into educational environments to optimize learning outcomes and promote increased student engagement. Incorporating neuroscience principles into the design of educational settings has immense potential for enhancing focus, learning, innovation, and overall academic success. Nevertheless, investigating this correlation is intricate due to the diverse array of variables involved and the interconnected cognitive-emotional and neurophysiological effects they generate. Consequently, numerous variables in this field have yet to be fully explored.

Accordingly, this research aims to investigate a relatively unexplored physical factor, specifically, the impact of the slope of a classroom ceiling on stress-induced arousal and cognitive performance among university students. To overcome existing limitations, the researchers utilized VR simulations to recreate classroom settings, measuring stress levels and cognitive performance through the N-back test and physiological responses. The research aimed to answer two central questions:
(1) Does the orientation of the ceiling slope, particularly in relation to visibility of the class board, have a significant impact on students' stress levels and cognitive performance?
(2) How do different orientations of the ceiling slope influence physiological processes related to stress-induced arousal and cognitive performance?

Review of the Related Literature

In its emerging phase, neuro-architecture primarily concentrated on comprehending and improving the design and functionality of spaces related to healthcare [2]. These settings were considered as essential due to their impact on human health and well-being. Early studies in neuro-architecture often examined hospitals [3], clinics [4], and healthcare facilities [5] to explore how the physical environment could influence factors like stress levels, attention span, and overall emotional and cognitive performance. By incorporating insights from neuroscience, architecture aimed to develop spaces that promote healing, comfort, and enhanced performance [6].

Neuro-architecture, initially introduced in healthcare design, has witnessed significant advancements that have extended its application to various architectural domains, including learning environments [7]. Recently, this approach has been employed in educational settings to enhance learning outcomes [1, 8, 9] and promote student engagement [10]. The incorporation of neuroscience principles into the design of learning environments holds immense potential in fostering concentration, learning, creativity, and overall academic performance. By understanding the neural mechanisms that govern our interactions with the built environment and recognizing the profound influence of architectural design on human cognitive processes, the field of neuro-architecture paves the way for innovative and insightful approaches to constructing spaces that facilitate optimal learning experiences. Neuro-architecture provides a diverse range of methodologies, experimental settings, and assessment tools to explore the impact of environmental and architectural stimuli as independent variables on students' unique conditions and characteristics as dependent variables.

Research in neuro-architecture for learning environments has been conducted in two distinct settings: physical and virtual. The first group involved participants interacting with real built environments [11-13], while the second group explored immersive virtual environments [14-16]. Although studies have traditionally focused on real settings, recent developments have shifted towards using virtual reality (VR) environments. Review papers note a growing interest in merging neuroscience with learning by leveraging VR technology to create realistic simulations [17]. VR enables researchers to create interactive computer simulations that provide users with a realistic sense of 'being there' in a space that does not feel synthetic [18]. Additionally, VR allows for efficient and cost-effective manipulation and isolation of variables in controlled laboratory conditions, which would be impractical in real-world settings. However, limitations exist in these studies related to the methods used to create virtual environments and the monitoring of environmental factors [19]. These constraints could impact our comprehension of the specific characteristics and manipulations in virtual environments and their potential implications. Moreover, it is important to validate the results of VR applications, which is why many studies have utilized the System Usability Scale (SUS) questionnaire to validate VR environments [20]. SUS is the most widely used standardized questionnaire for the VR assessment of perceived usability [21].

A review of relevant literature reveals that previous research has explored various independent variables in neuroarchitecture studies of learning spaces. These variables focus on environmental aspects such as classroom physical features (e.g., size and ceiling height), temperature, thermal comfort, acoustics, lighting, and wall colors. Findings indicate that classroom size, particularly width, impacts memory and attention, with narrower widths correlating to enhanced performance in memory tasks [15]. Brühwiler and Blatchford's study examining the impact of classroom size on learning progress concluded that smaller class sizes positively influence students' learning advancements. Additionally, ceiling height has been found to affect attention, with lower ceilings linked to quicker reaction times and improved performance [10, 22].

Color also plays a pivotal role in shaping the classroom atmosphere [23]. Color influences the classroom ambiance, with cooler hues boosting focus and memory retention [24]. Conversely, bright and vibrant colors can enhance learning outcomes [11, 25]. A study conducted in actual classrooms examined three color categories: neutral, warm, and cool. Cream represented the neutral tone, pink the warm tone, and blue the cool tone. The findings unequivocally demonstrate that the utilization of diverse colors in a classroom setting significantly impacts the perceptual abilities of male students [26].

Regarding lighting, research suggests that classrooms with ample natural light from spacious windows enhance learning outcomes, especially for reading and science activities [12]. Inadequate or unsuitable lighting may impede visual learning tasks like reading, impacting students' performance and attitudes [7, 27]. Furthermore, notable increments in ambient light can impact memory and learning [24]. The color temperature of lighting is also noted to impact cognitive processing, with higher temperatures linked to increased cognitive processing [28].

Furthermore, acoustics can play an important role in the learning process, with factors like noise, reverberation, and distance between the speaker and listener impacting students' perception of spoken information in the classroom [29, 30]. Studies have indicated that sound can impact the way speech is perceived. For example, one study replicated a scenario where a teacher spoke one meter away in a noisy environment to explore its impact on student learning [31]. Other studies highlight the significance of indoor environmental quality (IEQ) elements like thermal comfort, temperature, view, and ventilation in educational spaces [8, 32]. Research has demonstrated that indoor air quality has a significant impact on students' academic performance in educational settings. A conducive indoor air quality enhances college students' performance and contributes to attaining high levels of academic achievement within educational institutions [33].

The impact of the mentioned independent variables on various dependent variables has been investigated in neuro-architectural studies in learning environments. These include memory [34], attention [35], emotional response [36], cognitive function [27], educational engagement [11], learning advancement [10, 37, 38], mood [39], sensation [27], perception [26], perceptual ability [8], and alertness [40]. Memory and attention are the most studied neurological variables, followed by perception, learning, and cognitive performance. However, neurological variables such as stress, alertness, interaction, focus, visual perception, and emotional reaction have also received attention. Memory, vital for knowledge retention and application, is of significant importance as a dependent variable in educational settings [16]. Attention has also been extensively studied in relation to these dependent variables, with research measuring attention through reaction time and performance [41]. Cognitive performance has been another focal point examined in the reviewed literature [28]. Neuro-architectural studies often prioritize memory, attention and cognitive performance within learning environments due to their extensive research in the field of neuroscience, where its mechanisms and neural correlates have been extensively explored and understood. The emphasis on these factors in neuro-architectural studies could be attributed to their compatibility with commonly used analysis techniques such as Electroencephalography (EEG). EEG allows researchers to directly measure brain activity associated with memory and cognitive processes, facilitating a deeper understanding of how the built environment impacts memory formation and cognitive performance.

It is worth noting that despite various tools available for measuring stress-induced arousal in neuro-architectural research, such as neurophysiological data like EEG and physiological data including heart rate and skin conductance, quantitative studies exploring stress as a neural factor in classroom settings are scarce. Stress has been linked to decreased performance in children and adolescents [42]. Multiple studies have consistently found that students reporting lower stress levels related to personal and school matters tend to achieve higher GPAs [43], demonstrate increased academic success [42], and are less inclined to engage in behaviors that may harm performance, such as skipping school or quitting altogether [44].

After the investigations, it is clear that stress has not been given enough focus as a key factor in enhancing students' learning. Additionally, it is notable that there is a lack of studies examining how the shape, form, or slope of classrooms' ceilings affect students' stress levels and cognitive abilities. Therefore, this is an area that will be explored in the current study. This research aims to investigate the influence of changing the slope of classroom ceilings on students' stress levels and cognitive performance.

Our analysis uncovers intriguing patterns in utilizing experimental methods to explore the effects of design characteristics on educational environments through theories and practices of neuro-architecture. Previous research predominantly depended on qualitative surveys and observations, with minimal implementation of physiological or neurological instruments [8, 10, 31, 35, 36, 45]. However, as the discipline has advanced, there has been a shifting inclination towards utilizing physiological devices like heart rate monitors and skin conductance sensors, as well as neurological instruments such as electroencephalography (EEG). Consequently, in our present investigation examining the influence of classroom ceilings on students' stress levels and cognitive abilities, we have incorporated physiological sensors and cognitive performance tests.

Method

Participants

A total of 18 participants took part in the experiment, consisting of 9 males and 9 females. The participants had an average age of 23.36 years, with a standard deviation (σ) of 4.64. To maintain the study's consistency and reliability, five inclusion criteria were established for selecting participants, drawing from findings in systematic review papers related to previous similar research [46]. Firstly, participants needed to be university students to ensure they were familiar with the classroom environment and could provide relevant insights[11, 20, 33]. Secondly, they were required to have normal or corrected-to-normal vision using contact lenses, as the use of spectacles with the HMD could potentially introduce complications or discomfort [14, 15]. Thirdly, the age range for participants was set between 20 and 28 years to ensure a relatively homogeneous sample within a specific age bracket [13, 32]. This helped minimize potential confounding factors associated with age-related differences in cognitive processing. Fourthly, participants needed to be born and currently reside in Iran. This criterion aimed to avoid potential cultural effects and variations that may arise from participants with different cultural backgrounds [46]. Lastly, participants were required to have abstained from consuming performance-altering substances, such as caffeine, within the 24 hours preceding the experiment. This criterion was put in place to minimize the potential influence of substances on participants' physiological and cognitive responses during the study [16, 32]. By implementing these inclusion criteria, the study aimed to ensure a consistent and homogeneous participant group, enabling more valid and reliable results.

Instruments

The participants in the study utilized a virtual head-mounted display (VR HMD) to visualize the different CSVs (as shown in Figure 1). All research activities were conducted within the same laboratory setting. The HMD device utilized in the research was the HTC Vive. This device offers a total resolution of 2160 × 1200 pixels, with each eye having a resolution of 1080 × 1200 pixels. The refresh rate of the device was set at 90Hz, and it provided a field of view of 110 degrees. These specifications ensured a high-quality visual experience for the participants during the simulations. The simulations of the different classrooms were created through a process of modeling and rendering. SketchUp Pro (v23.1.340) was used for the 3D modeling phase, allowing for the creation of a virtual representation of the classroom spaces. Twinmotion (v.2021.1×64) was then utilized for the rendering process, enhancing the visual quality of the virtual environments. Additionally, Twinmotion was used for the virtual implementation of the simulations. Throughout the experiments, the perspective of a student sitting in the middle of the fourth row of tables was maintained. This viewpoint was chosen to provide a comprehensive understanding of the entire classroom space during the duration of the experiment. By adopting this perspective, participants were able to observe and interact with the virtual environment from a position that closely resembled their typical seating arrangement in a physical classroom.

To gather physiological data from participants, the research utilized the Open BCI Emotibit bio-datalogger. The EmotiBit is a wearable device specifically crafted for capturing and monitoring emotional, physiological, and kinetic information in real-time. This compact and lightweight gadget comes equipped with sensors capable of overseeing a broad spectrum of biometric parameters, enabling researchers to stream over 16 data channels from the individual's body. These include PPG for heart rate, heart rate variability, respiration, oxygen saturation, and hydration; EDA/GSR for electrodermal activity and galvanic skin response, demonstrating sympathetic nervous system reactions triggered by cognitive and emotional stimulation; a 9-axis IMU for deriving movements, activity, gestures, rotation, and cardinal direction; and body temperature assessment for health and emotional response evaluations. EmotiBit offers scientifically validated sensing technology that is open-source and Arduino-compatible, allowing wireless data streaming to any platform for real-time insight into the participant's dynamic physiological and cognitive processes. This enables researchers to log participants' physical and psycho-emotional alterations throughout any specific timeframe and monitor real-time biometric data changes to establish a comprehensive long-term physiological profile.

Procedure

The research study employed a quasi-experimental design to investigate the research objective. The main focus was to examine the impact of different variations of ceiling slopes, known as CSV (Ceiling Slope Variations), on participants' stress-induced arousal and cognitive performance. The study utilized a VR setting to present participants with various CSV configurations. Data was collected through cognitive performance tests and psychological responses. The analysis of the study was divided into three phases, each addressing specific research questions.

In the first phase, the participants' stress levels were assessed based on the different ceiling slope variations. This was measured using psychological responses, including heart rate variability (HRV) and electrodermal activity (EDA). The aim was to determine if different ceiling slope orientations had a significant impact on participants' stress levels.

The second phase focused on evaluating participants' cognitive performance based on the ceiling slope variations. This was done using the N-back test, a cognitive task that measures working memory and attention. The objective was to determine if different CSV configurations influenced participants' cognitive performance.

The third phase of the analysis involved examining the correlation between participants' psychological and physiological responses. This step aimed to explore the relationship between stress-induced arousal and cognitive performance based on the different ceiling slope orientations. Prior to conducting the analyses, the validity of VR environment used in the study was assessed. This was done by evaluating the participants' sense of presence, ensuring that the VR simulation effectively created an immersive classroom environment. The provided figures (1 and 2) illustrate the general outline of the methodology employed in the study, showcasing the three phases of analysis and the overall research design.

In this study, a virtual representation of a classroom at the Faculty of Art and Architecture in Shiraz University was created. The selection of this particular classroom was based on its representativeness of typical physical teaching spaces found in universities. The simulated classroom had dimensions of 8.20×5.50×3.80 meters and was designed to reflect the neutral characteristics of an actual classroom.

To explore the impact of different ceiling slopes on student arousal and cognitive performance, two additional classrooms were simulated. These classrooms featured a 10% sloping ceiling with a height of 90 centimeters. The simulations were conducted under three scenarios: 1) the ceiling sloping towards the classroom board, 2) the ceiling sloping towards the end of the classroom, and 3) a neutral classroom without any slope (as depicted in Fig. 1).

The aim of these simulations was to examine how the viewing angle of students, determined by the orientation of the ceiling slope, influenced their levels of stress-induced arousal and cognitive performance. By comparing the responses of participants in the different simulated classrooms, the study sought to understand the relationship between ceiling slope variations and student well-being and academic performance.

The Design of Study

The experiment process can be summarized as follows (see Fig. 2):

- **Participants' System Usability Scale (SUS) Questionnaire Evaluation**: The participants were asked to complete the SUS questionnaire, which includes ten items that are rated on a Likert scale ranging from 0 to 4. The aim of this questionnaire was to evaluate the level of satisfaction among participants and determine whether the virtual reality simulations were deemed satisfactory.
- **VR Immersion and Physiological Recordings**: After completing the SUS questionnaire, participants were immersed in a simulated environment using VR technology for 6 minutes and 30 seconds. During this time, their heart rate variability (HRV) and electrodermal activity (EDA) data were recorded using the Emotibit device (Fig.1). These data were recorded to evaluate the arousal induced by stress in each environment.

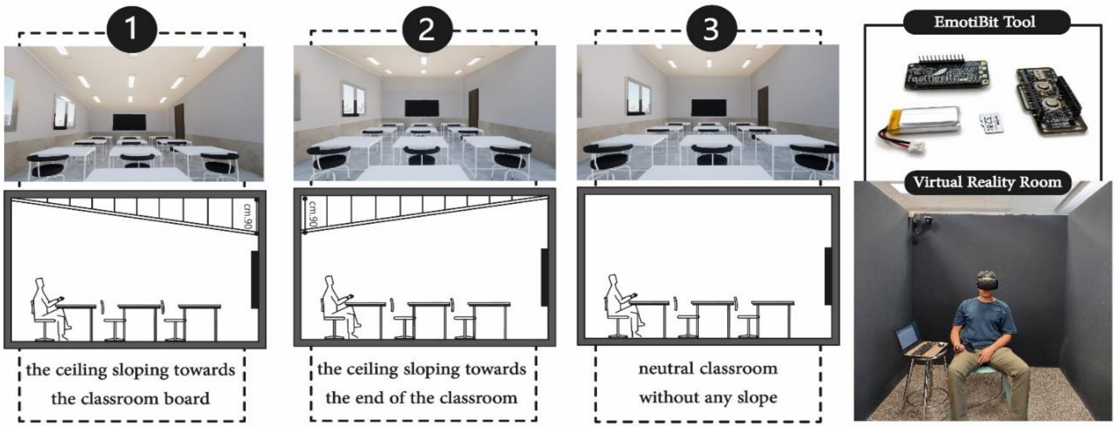


Fig. 1: The simulated environment, experimental setting, and utilized tools for the experiment.

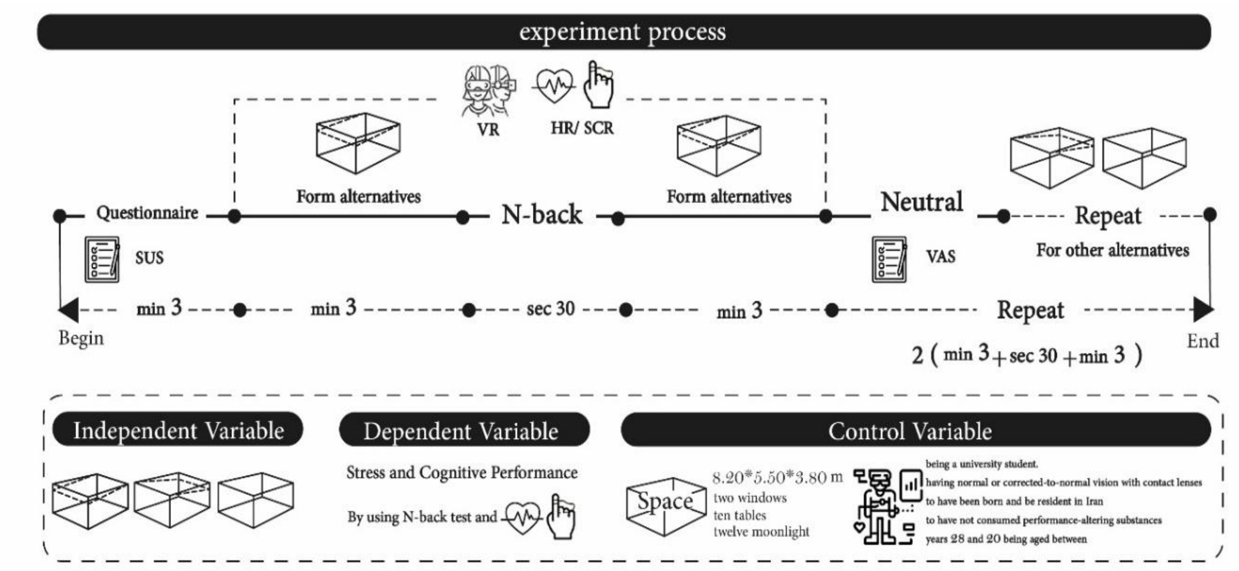


Fig. 2: Experiment process and variables

- **Cognitive Performance Testing (N-back test)**: After spending three minutes in each simulated space, participants were presented with the N-back test displayed on a simulated classroom board. They were asked to respond to the test while their physiological data was simultaneously recorded. The N-back test served two purposes in the experiment: first, to induce stress in participants and assess the impact of the environment on their stress levels before and after the test, and second, to measure participants' cognitive performance in the environment.
- **Visual Analogue Scales (VAS) Questionnaire Evaluation**: The objective of this questionnaire was twofold, to determine the level of stress induced by each environment on the participants and to assess the stress-inducing nature of the N-back test in each environment. This evaluation aimed to ensure that the N-back test elicited a similar level of stress across all environments and to control for stress factors in the experiment.
- **Statistical Analysis**: The data collected, both through the N-back test and psychological responses, were subsequently utilized to conduct the necessary statistical analyses to investigate the study questions. physiological data was extracted using the Emotibit device software. Furthermore, GraphPad Prism software (v.9.1.0) was employed for this purpose.

Results and Findings

Validation of the VR CSV

In the study, a cohort of 27 university students took part in the SUS questionnaire administration. Out of the participants present in the experiment, only 18 achieved a score exceeding 50%, which was set as the threshold for measuring satisfaction with the VR HMD simulation. Fig. 3 illustrates the average sense of presence levels per participant as assessed through the SUS questionnaire.

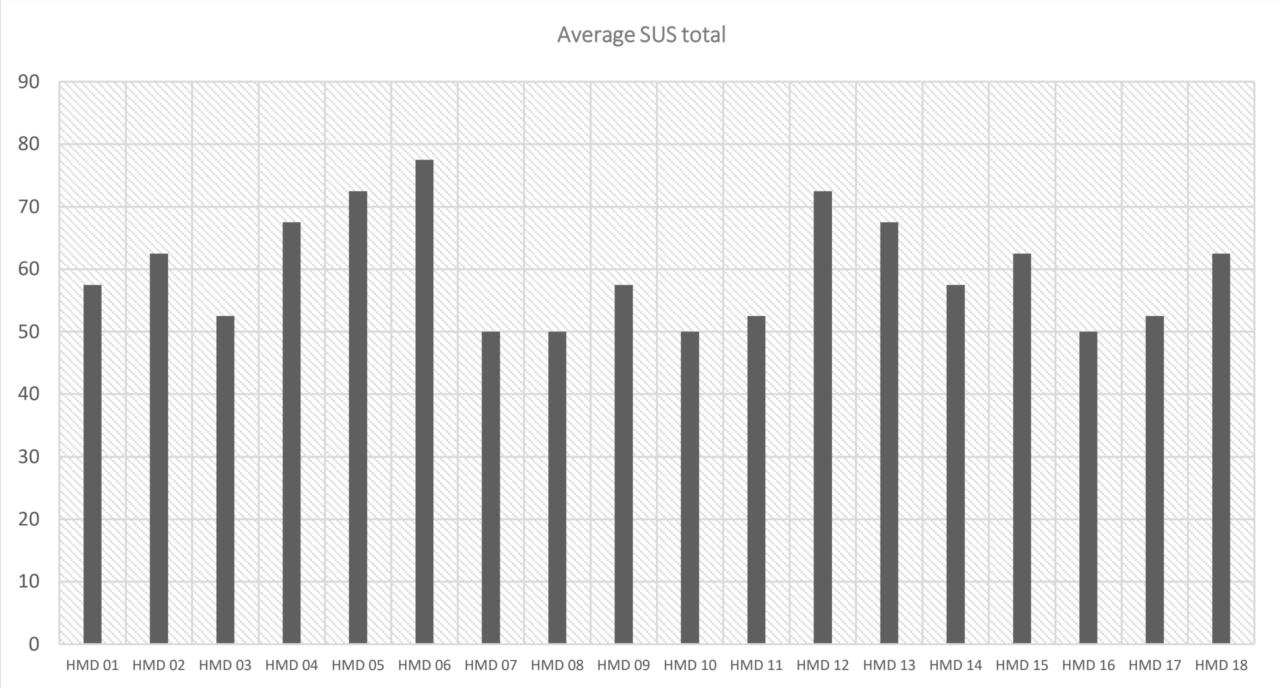


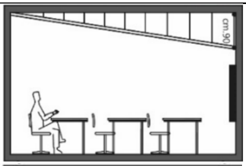
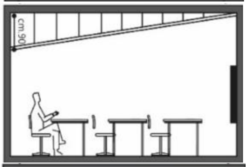
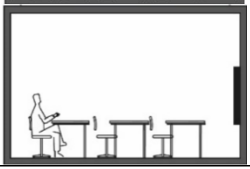
Fig. 3. The average level of sense of presence per participant

Analysis of the N-back cognition performance test

The N-back test is a common task used in cognitive psychology and neuroscience research to assess working memory. In this test, individuals are required to continuously monitor a series of stimuli and remember if the current stimulus matches the one that occurred "n" steps back in the sequence. The "n" can vary, with higher values typically indicating greater cognitive demand. By performing the N-back test, researchers can gain valuable information about an individual's working memory capacity and cognitive control abilities. In the current study, the N-back test is a versatile tool used for cognitive assessment with various purposes. In addition to inducing stress during the experiment and measuring stress-related arousal levels, it is also utilized to evaluate cognitive functions such as attention, working memory, and decision-making [32]. This evaluation is important for gaining insights into an individual's cognitive abilities and performance levels. The results of the N-back test are analyzed and documented in Table 1 to provide a comprehensive assessment of cognitive function.

According to the analysis, it was found that individuals performed exceptionally well in Form (2) of the cognitive assessment, with an impressive 22.26% accuracy rate in providing correct answers. Moreover, they exhibited the lowest rate of incorrect answers, standing at just 11.34%. These results signify a high level of cognitive proficiency and a strong ability to respond accurately to the tasks presented in scenario (2). Conversely, scenario (3) displayed the poorest cognitive performance, with only 18.06% of answers being correct. Additionally, it had the lowest rate of higher answers, which amounted to 14.74%. These findings suggest a relatively lower level of cognitive functioning and a higher likelihood of errors in responding to the stimuli or tasks presented in the scenario (3). Also, scenario 1 has a slight difference in the rate of incorrect responses compared to scenario (2).

Table 1: Results of the N-back cognitive performance test

Nu. scenario		N-back result					HRV	EDA
		T	T(%)	F	F(%)	all	(mean)	(mean)
scenario 1		51	21.42%	29	12.18%	80	76.62	3.6
scenario 2		53	22.26%	27	11.34%	80	80.8	3.78
scenario 3		43	18.06%	35	14.74%	78	78.9	2.68

To calculate the percentage, the total sum of responses is 238.

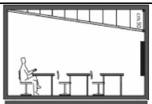
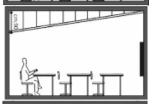
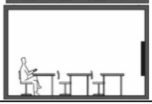
Analysis of the physiological responses

The EmotiBit device is a physiological sensor system that can measure various physiological signals, such as heart rate variability (HRV) and electrodermal activity (EDA), to provide insights into individuals' emotional and stress responses. By monitoring these physiological indicators, researchers can gain a better understanding of the impact of stress on individuals. Heart rate variability (HRV) is a commonly used physiological measure that reflects the number of times the heart beats per minute. During periods of stress, the body's sympathetic nervous system is activated, leading to an increase in heart rate. Monitoring changes in heart rate can provide valuable information about an individual's physiological response to stress [12, 47]. Electrodermal activity (EDA), also known as *galvanic skin response* or *skin conductance*, is another measure that can indicate emotional arousal and stress levels. It measures the electrical conductance of the skin, which is influenced by sweat gland activity. When a person experiences emotional arousal or stress, there is an increase in sweat gland activity, leading to changes in skin conductance [11, 48-50].

In this study, the EmotiBit device was utilized to measure Heart Rate Variability (HRV) and Electrodermal Activity (EDA) in individuals both before and after engaging in a stress-inducing task known as the N-back test in different virtually simulated scenarios. The N-back test is not only used to assess cognitive performance but also to induce stress in the participants. By analyzing the differences in HRV and EDA levels before and after the test in each scenario, we can evaluate how the classroom environment responds to stress. The findings of this comparison are presented in Table 2.

The Analysis of Variance (ANOVA) test is a robust statistical method used to compare means among three or more groups. In this study, we employed ANOVA to explore the impact of varying simulated ceilings' slope orientations on individual stress levels. Specifically, we conducted an ANOVA analysis to determine whether there were significant differences in stress levels before and after administering the N-back test in each scenario.

Table 2: Results of the physiological responses (HRV & EDA)

Scenario Number		HRV			EDA				Significancy
		P value HRV	Before test (mean)	After test (mean)	P value EDA	Before test (mean)	After test (mean)	Difference	
scenario1		0.41	76.85	78.84	0.13	3.17	3.67	-0.5	ns
scenario 2		0.58	79.32	77.63	0.35	3.55	2.67	0.88	ns
scenario 3		0.34	77.53	78.56	0.82	3.20	3.11	0.09	ns

ns=Not Significant (P < 0.05 is considered as Significant)

Accordingly, we conducted an ANOVA analysis on the Heart Rate Variability (HRV) and Electrodermal Activity (EDA) data of 18 participants to assess changes in stress levels across different scenarios. Specifically, we examined whether there was a significant difference in stress levels before and after each scenario, with a focus on the mean HRV and EDA values as indicators of stress.

Our analysis sought to identify scenarios where stress levels remained consistent before and after the experiment, as evidenced by non-significant changes in HRV and EDA readings. Desirability in this context was defined by results with higher p-values, signifying a lack of significance. Essentially, it was aimed to determine if the mean stress levels of each scenario accurately reflected the overall stress experienced by participants.

In essence, the findings revealed that stress levels did not significantly vary before and after the N-back test, with a p-value greater than 0.05 indicating no discernible difference in HRV and EDA responses pre and post-test. This suggests that the scenarios examined did not have a substantial impact on participants' stress levels, irrespective of individual differences in EDA and HRV measurements.

Based on the analysis of physiological data utilizing ANOVA, it was determined that there were no significant differences observed across all three scenarios. Notably, scenario 2 (refer to Fig. 1) exhibited the highest P-value for HRV at 0.58, with an EDA difference of 0.88. Conversely, scenario 3 displayed the lowest outcomes, indicating a P-value for HRV of 0.34 and an EDA difference of 0.09.

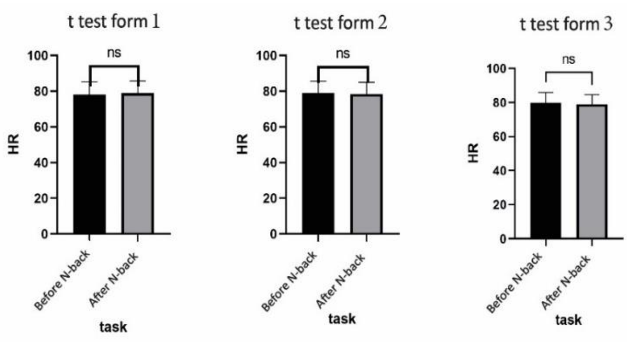


Fig. 4: Results of the physiological responses (HRV & EDA) according to the ANOVA test.

Visual Analogue Scales (VAS) Questionnaire

Visual analogue scales (VAS) are psychometric measuring instruments designed to capture and quantify stress levels in surveyed individuals, enabling a swift and reliable classification of perceived stress. Operating on a scale of 1 to 10, VAS offers a straightforward and user-friendly method for participants to articulate their stress levels, streamlining data collection processes. By using the VAS Questionnaire, researchers can obtain precise and quantitative measurements of participants' stress levels, facilitating an accurate analysis of stress factors and trends.

The findings from the VAS questionnaire revealed that the inclusion of the N-back test as a controlled variable induced similar levels of stress across all scenarios. Specifically, stress levels varied marginally, with a stress-inducing effect of 33.59% in scenarios 2 and 3, and 32.82% in scenario 1. Additionally, an analysis of individual stress susceptibility highlighted that scenario 3 elicited the highest stress levels, followed by scenarios 1 and 2, which exhibited comparatively lower levels of stress.

Correlation between the cognition performance and the physiological and VAS responses

The results of the analysis provide further insights into the relationship between different classroom forms (scenario 1, scenario 2, and scenario 3) and cognitive performance as well as stress levels. Scenario 3, being the common and prevalent form in classroom settings, was found to have the lowest cognitive performance among the individuals. This suggests that the layout or design of scenario 3 may not be optimized for cognitive performance. Additionally, it exhibited the highest level of stress among the participants, indicating that the environment created by scenario 3 may be more stressful or less conducive to a relaxed and focused state of mind. In contrast, scenario 2, characterized by a backward sloping ceiling towards the back of the classroom, demonstrated the most desirable state in terms of cognitive performance and stress levels. The layout of scenario 2 seems to support better cognitive functioning, potentially allowing for improved attention and concentration. Moreover, individuals in scenario 2 experienced lower levels of stress, indicating a more conducive and comfortable learning environment. Interestingly, although participants rated scenario 1 with the lowest score in terms of perceived environmental stress based on the VAS questionnaire, the results from both the physiological data and the N-back test analysis consistently favored scenario 2, albeit with a slight difference compared to scenario 1. This suggests that the objective measurements of cognitive performance and stress levels align more closely with the superiority of scenario 2, despite the participants' subjective perception of stress in scenario 1.

Discussion

In the current study, multiple experimental phases were conducted to investigate the relationship between different classroom ceiling orientations (scenarios 1, 2, and 3) and their impact on cognitive performance and stress levels. Initially, participants completed a System Usability Scale (SUS) questionnaire to assess their compatibility with VR simulations. Those who scored below the standard were removed from subsequent study phases. In the next phase, physiological data, including heart rate variability (HRV) and electrodermal activity (EDA), were collected using an Emotibit device while participants experienced virtual classrooms with varying ceiling slopes in different scenarios. Cognitive performance was measured using the N-back test, which also served as a stress-inducing task. Moreover, participants' stress levels were evaluated through a Visual Analog Scale (VAS) questionnaire. The analysis of the results provides valuable insights into the relationship between different classroom ceiling orientations and their impact on cognitive performance and stress levels.

Table 3. Results of VAS questionnaire evaluation

VAS Result	Scenario			N-back		
	Scenario 1	Scenario 2	Scenario 3	N-back scenario 1	N-back scenario 2	N-back scenario 3
Sum	32	34	43	42	43	43
Percentage	29.35%	31.19%	39.46%	32.82%	33.59%	33.59%

The experiment's findings are presented in two key categories. The first category focuses on how various ceiling slope scenarios impact cognitive performance. By evaluating performance on the N-back test across different scenarios, we measured participants' accuracy in responding to the test stimuli. The level of correct responsiveness in this test is directly linked to cognitive performance desirability. Interestingly, the results highlighted that Scenario 2, featuring a backward-sloping classroom ceiling, showed heightened correct responsiveness and significantly higher cognitive performance desirability compared to other scenarios. Conversely, Scenario 3, with a flat ceiling in the classroom, exhibited lower cognitive performance desirability.

The second category delves into the findings concerning how different forms impact surveyed participants' stress levels. Physiological data, such as Electrodermal Activity (EDA) and Heart Rate Variability (HRV), were examined to gauge these effects. Through statistical analysis using ANOVA, changes in individuals' physiological responses before and after exposure to stress-inducing scenarios were determined.

The findings revealed that Scenario 2 had a more pronounced effect on stress level reduction compared to other scenarios. To corroborate these results, a VAS questionnaire was concurrently administered to participants. By capturing self-reported stress levels in each scenario, the questionnaire enabled a cross-reference with the physiological data for a comprehensive analysis. The outcomes further illustrated that Scenarios 1 and 2 elicited lower stress levels in comparison to Scenario 3. Furthermore, the validation through the VAS questionnaire highlighted that the N-back test, functioning as a control, elicited a consistent level of stress across all scenarios, with minimal deviations detected.

Notably, the study found that scenario 3, the most commonly observed configuration in classroom settings, was associated with the lowest cognitive performance among participants. This implies that the design of flat ceilings may not be ideal for optimizing cognitive abilities. Furthermore, individuals in scenario 3 reported the highest stress levels, suggesting that this particular layout may create a more stressful environment that is less conducive to relaxation and concentration.

In contrast, scenario 2, distinguished by its sloping ceiling that angles towards the back of the classroom exhibited the most optimal conditions for cognitive performance and stress reduction. The design of scenario 2 appears to promote enhanced cognitive abilities, fostering improved attention and concentration among individuals. Additionally, participants in scenario 2 reported decreased stress levels, suggesting a more relaxing and conducive atmosphere for learning.

Surprisingly, while participants rated scenario 1 as having the least perceived environmental stress according to the VAS questionnaire, both the physiological data and N-back test results consistently favored scenario 2. Though the difference from scenario 1 was slight, this indicates that objective measures of cognitive performance and stress levels more strongly support the superiority of scenario 2, contrasting with participants' subjective stress perception in scenario 1.

The neuro-architectural study discussed here highlights the significant impact of ceiling slope variations, particularly backward sloping ceilings, on reducing stress levels and enhancing cognitive performance in students. This underscores the importance of incorporating neuro-architectural considerations in classroom design to cultivate environments that foster optimal learning and well-being. It is noteworthy that current university classrooms predominantly feature flat ceilings, which have been linked to lower cognitive performance and heightened stress levels among participants. This underscores the need for further exploration into the transformation of classroom environments to facilitate an ideal learning space. Moreover, the limited research on stress and cognitive performance as pivotal elements in improving students' learning experiences in educational settings accentuates the urgency for more in-depth investigations in this area.

Neuro-architecture, a cutting-edge field merging neuroscience and architecture, has made significant progress in deciphering how design influences individuals. This interdisciplinary approach has gained momentum, particularly in the realm of educational settings, with the primary objective of elevating learning results and fostering student engagement. Through the integration of neuroscience principles into the design process, educators and architects aspire to provide environments that foster heightened concentration, learning retention, creativity, and overall academic performance. Nevertheless, unraveling the intricate dynamics between neuroscience and learning environment design proves to be a challenging task, given the vast array of variables at play and the interrelated effects on cognition, emotion, and neurophysiology. Consequently, numerous unexplored facets remain in this burgeoning field.

To forge ahead, future studies should delve deeper into the correlation between learning environments' physical characteristics and learning outcomes, considering a wider spectrum of variables for a comprehensive analysis. Furthermore, investigations on the impact of form, scale, and proportion in classroom design warrant attention. Stress and cognitive performance, acknowledged as pivotal elements in enhancing students' learning journeys, deserve further scrutiny. By delving into these realms, researchers can advance the establishment of evidence-based design principles that optimize learning environments for students.

Conclusions

In conclusion, this research underscores the crucial importance of educational space design in mitigating stress and enhancing cognitive abilities in students, in line with the principles of neuro-architecture. The study delves into the specific impact of varying classroom ceiling slopes on stress-induced arousal and cognitive functionality in university students. Through the innovative use of VR simulations and the measurement of both physiological and cognitive responses, this research provides significant insights into how different ceiling slope orientations can affect stress levels and cognitive performance. These findings demonstrate that the orientation of the ceiling slope, particularly its visibility in relation to the class board, plays a key role in influencing stress levels and cognitive functioning among students.

The study reveals that different ceiling slope orientations not only impact cognitive processes but also influence physiological responses linked to stress arousal. Notably, a backward sloping ceiling design demonstrates the highest accuracy rate and lowest rate of incorrect answers, indicating superior cognitive abilities compared to the standard classroom layout. Conversely, the traditional classroom design displays the poorest cognitive performance.

Furthermore, the study identifies that ceiling slope variations trigger changes in students' physiological reactions, reflected in alterations in heart rate and skin conductance, ultimately leading to varying levels of stress among students. These findings underscore the essentiality of incorporating neuro-architectural considerations, such as ceiling slope orientation, in educational space planning. The research suggests that incorporating a backward sloping ceiling can notably decrease stress levels and enhance cognitive performance in students. Thus, emphasizing neuro-architectural factors in classroom design is vital to establishing conducive learning environments that promote optimal academic performance and student well-being.

Authors' Contribution

Reyhaneh Raisi was responsible for software simulations; conceptualization; resources; results and analysis; writing the original draft; and visualization.

Kaveh Fattahi was responsible for conceptualization; methodology; results and analysis; writing, reviewing and editing the manuscript; and supervision.

Seyed Mohammad Hossein Zakeri was responsible for conceptualization; methodology; results and analysis; writing, reviewing, and editing the manuscript; and supervision.

Sara Daneshmand was responsible for conceptualization; methodology; results and analysis; and writing, reviewing and editing the manuscript; and supervision.

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Conflicts of Interest

The authors would like to declare that there is no conflict of interest regarding the publication of this paper. We confirm that our research has been conducted objectively and without any influence from any financial or personal relationships that could be perceived as a conflict of interest .

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ORIGINAL RESEARCH PAPER

Iranian Pre-Service EFL Teachers' TPACK Competencies: A Case Study of Semnan Farhangian University

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ABSTRACT

Background and Objectives: Over the past decades, the integration of technology in education has transformed how various subjects are taught and learned. This trend has also impacted English as a Foreign Language (EFL) education, opening up new possibilities for interactive learning, global communication, and cultural exchange through online tools and platforms. The increasing demand for engaging and interactive learning experiences has made it essential to train pre-service EFL teachers (PSEFLTs) in effectively merging technology and EFL instruction, allowing them to leverage the benefits of digital tools and resources. This training can begin with an assessment of their current Technological Pedagogical Content Knowledge (TPACK). To this end, the current study seeks to explore PSEFLTs' perceived TPACK competencies and their actual practices for incorporating technology into their teaching, ultimately enhancing their effectiveness in diverse educational contexts.

Materials and Methods: Ten undergraduate students enrolled in an English Language Teaching (ELT) program at Semnan Farhangian University in Iran were recruited, comprising six females and four males selected through purposive sampling. They were in their last year of their academic program. This study employed a qualitative case study design, with data collected through semi-structured interviews and classroom observations. The open-ended interview questions and observation checklist were formulated based on a review of the literature on TPACK. In this study, the EFL teacher educators acted as peer debriefers, which contributed to enhancing the validity of the research. Pilot interviews and observations, member-checking, and data triangulation were also conducted to strengthen the credibility of the study. To analyze the data, the researcher employed thematic analysis.

Findings: The findings indicated that while PSEFLTs demonstrated a solid foundation in CK, PK, and PCK, their TK, TCK, TPK, and TPACK competencies appeared to be limited. Specifically, the PSEFLTs exhibited a strong grasp of the content and effective teaching strategies; however, their understanding and application of technology in educational contexts were insufficient. This gap suggests that despite having the necessary knowledge to teach effectively, they struggled to integrate technological tools and resources into their instructional practices. Observations also revealed a limited use of technology for student-centered learning.

Conclusions: The findings of this study shed light on a concerning gap in the current Iranian pre-service EFL teacher education programs, indicating that future teachers, while possessing strong content and pedagogical content knowledge, are not adequately equipped with the essential TPACK foundation needed to incorporate technology into their teaching methodologies seamlessly. This deficiency in preparing pre-service teachers in the integration of technology could potentially impede their effectiveness in delivering engaging and innovative instruction to their students. The implications of this study extend beyond the classroom, calling attention to the need for policymakers, curriculum developers, and material planners to reassess and enhance teacher training programs to better align with the demands of the 21st-century educational landscape. By effectively addressing the identified weaknesses in the TPACK of PSEFLTs, stakeholders can equip them with the necessary knowledge and skills to utilize the potential of technology in teaching, thereby significantly improving student learning outcomes and fostering a more engaging educational environment.

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55
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0
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4

مقاله پژوهشی

بررسی شایستگی‌های دانشجومعلمان ایرانی رشته آموزش زبان انگلیسی در دانش فن‌آوری، تربیتی، موضوعی و تربیتی- موضوعی (مطالعه موردی: دانشگاه فرهنگیان سمنان)

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چکیده

پیشینه و اهداف: در طول دهه‌های گذشته، ادغام فناوری در آموزش، شیوه های تدریس و یادگیری موضوعات مختلف را متحول کرده است. این روند بر آموزش زبان انگلیسی به عنوان زبان خارجی نیز تأثیر گذاشته است و فرصت های جدیدی برای یادگیری تعاملی، ارتباطات جهانی و تبادل فرهنگی از طریق ابزارها و پلتفرم های آنلاین ایجاد کرده است. تقاضای فزاینده برای تجربیات یادگیری جذاب و تعاملی، آموزش به دانشجو معلمان رشته آموزش زبان انگلیسی در راستای ادغام موثر دو مقوله فن آوری و آموزش زبان را ضروری کرده است تا به آن ها امکان دهد از مزایای ابزارها و منابع دیجیتالی بهره مند شوند. این آموزش ها را می‌توان با ارزیابی دانش فن آوری، تربیتی، موضوعی و تربیتی-موضوعی آن ها آغاز کرد. مطالعه حاضر به بررسی و تحلیل نظرات دانشجو معلمان رشته زبان انگلیسی در خصوص شایستگی هایشان در دانش فن آوری، تربیتی، موضوعی و تربیتی-موضوعی و عملکرد واقعی آن ها در کلاس درس در استفاده از فن آوری می‌پردازد که در نهایت به افزایش اثربخشی آن‌ها در حیطه های مختلف آموزشی کمک می‌کند.

روش‌ها: ده دانشجوی سال آخر مقطع کارشناسی رشته آموزش زبان انگلیسی در دانشگاه فرهنگیان سمنان، ایران شامل شش زن و چهار مرد از طریق نمونه‌گیری هدفمند انتخاب شدند. در این تحقیق کیفی از روش مطالعه موردی استفاده و داده‌ها از طریق مصاحبه‌های نیمه‌ساختاریافته و مشاهدات کلاس درس جمع‌آوری شد. سوالات باز پاسخ مصاحبه و چک‌لیست مشاهده بر اساس مرور ادبیات تحقیق مربوط به الگوی تی پک طراحی شدند. بازبینی ابزار تحقیق توسط استادان رشته آموزش زبان انگلیسی، انجام مصاحبه‌ها و مشاهدات آزمایشی، بازبینی شرکت کنندگان و مثلث سازی داده ها به افزایش اعتبار مطالعه کمک کرد. برای تجزیه وتحلیل داده‌ها، پژوهشگر از روش تحلیل مضمون استفاده کرد.

یافته‌ها: نتایج نشان داد، در حالی که دانشجومعلمان از دانش موضوعی، دانش تربیتی و دانش موضوعی-تربیتی قوی برخوردار هستند، دانش و مهارت آن‌ها در دانش فن آوری، تربیتی، موضوعی و تربیتی-موضوعی محدود است. به‌طور خاص، دانشجومعلمان زبان انگلیسی دارای تسلط کافی بر محتوای درسی و شیوه‌های تدریس مؤثر بودند؛ با این حال، درک آن ها از فن آوری و توانمندیشان در استفاده از آن در امر تدریس ناکافی بود. این شکاف نشان می‌دهد که با وجود بهره مندی از دانش و مهارت لازم برای تدریس مؤثر، آن‌ها در ادغام ابزارها و منابع فن آورانه در تدریس با مشکل مواجه هستند. مشاهدات کلاسی نیز حاکی از استفاده محدود از فن آوری در امر آموزش به شیوه‌ی دانش‌آموز-محور بود.

نتیجه‌گیری: یافته‌های این مطالعه به وجود یک شکاف نگران‌کننده در آموزش دانشجومعلمان زبان انگلیسی به عنوان زبان خارجی در ایران اشاره دارد. این نتایج نشان می‌دهد که معلمان آینده در عین برخورداری از دانش موضوعی و دانش تربیتی-موضوعی قوی، از دانش فن‌آوری، تربیتی، موضوعی و تربیتی-موضوعی کافی برخوردار نیستند تا بتوانند در تدریس خود به‌طور مؤثر از آن استفاده کنند. این نقص در آماده‌سازی دانشجومعلمان به طور بالقوه می‌تواند بر عملکرد آن‌ها در ارائه آموزش‌های جذاب و نوآورانه به دانش‌آموزان تأثیر منفی بگذارد. پیامدهای این مطالعه فراتر از کلاس درس است و از سیاستگذاران، برنامه ریزان و مولفان کتاب های درسی می‌خواهد برنامه درسی دانشجومعلمان را بازبینی نموده و بهبود بخشند تا بهتر با نیازهای آموزشی قرن بیست و یکم همسو شود. با پرداختن موثر به نقاط ضعف شناسایی شده در زمینه‌ی دانش فن‌آوری، تربیتی، موضوعی و تربیتی-موضوعی دانشجومعلمان زبان انگلیسی، ذینفعان می‌توانند آن ها را با دانش و مهارت‌های لازم برای بهره گیری از ظرفیت های فن آوری در تدریس مجهز ساخته و بدین ترتیب، به طور قابل توجهی نتایج یادگیری دانش‌آموزان را بهبود بخشیده و یک محیط آموزشی جذاب‌تر ایجاد کنند.

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Introduction

In recent years, technology has transformed the landscape of education, offering new possibilities for teaching and learning. It is widely recognized that the COVID-19 pandemic has brought about significant changes in the way education is delivered, with a shift from traditional face-to-face instruction to online instruction [1]. While technology has become increasingly popular in education [2], its widespread availability doesn't automatically lead to effective use. This disconnect stems from a narrow focus on technology itself, with technology skills often taught in isolation from real-world context and pedagogical strategies. This separation hinders teachers' ability to understand how technology interacts with teaching methods and learning environments. Consequently, successful technology integration in education requires more than just providing computers and internet access [3]. It necessitates a holistic approach that considers the broader context and its implications for teaching and learning [4]. In the field of English language teaching (ELT), technology integration has become increasingly important as it provides opportunities to engage students, enhance language skills, and promote autonomous learning. To effectively teach, instructors must possess a strong foundation in three interconnected areas: technology, pedagogy, and content [5]. This understanding is known as Technological Pedagogical Content Knowledge (TPACK) and is crucial for delivering engaging and effective language instruction [6].

Pierson [7] initially proposed the concept of TPACK, which was further developed by other researchers who emphasized the importance of technology integration within specific subjects [8,9]. The influential work of Mishra and Koehler [10] significantly boosted the visibility and popularity of TPACK. The framework of TPACK builds upon Shulman's [11] model of PCK, adding the construct of technology [12]. Wang et al. [13] define TPACK as a teacher's intuitive grasp of how to bring together pedagogical knowledge and chosen technologies. In fact, TPACK is a framework that suggests teaching with technology is effective only when teachers utilize a combination of knowledge bases—specifically, technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK)—and can recognize the connections and interactions among these areas of knowledge [4].

TPACK in ELT can be defined as a framework that empowers teachers to use technology strategically to enhance the effectiveness and quality of language learning [14]. The success of technology-based language teaching hinges heavily on the effectiveness of teacher education programs for EFL teachers. These programs are crucial because they shape the knowledge and skills that teachers need to integrate technology effectively into language learning [15]. In fact, the importance of TPACK in pre-service ELT teacher education lies in its ability to prepare future teachers for the dynamic landscape of modern classrooms. By emphasizing the interconnectedness of technological knowledge, pedagogical strategies, and content mastery, TPACK encourages PSEFLTs to develop a comprehensive understanding of how to effectively integrate technology into their language instruction [16]. This framework enables them to critically evaluate and select appropriate digital tools and resources tailored to the diverse learning needs of their students [17]. Additionally, TPACK fosters a reflective teaching practice, prompting pre-service teachers to consider how their choices impact student engagement and learning outcomes [18]. Ultimately, cultivating TPACK in pre-service programs equips future EFL teachers with the essential skills and confidence to navigate the complexities of 21st-century education, enhancing their effectiveness in fostering language acquisition and critical thinking among learners [19].

There has been a recent surge in quantitative studies assessing PSEFLTs’ TPACK levels in Iran [4, 20, 21, 22] and in other EFL contexts [23,24,25,26,27]. For instance, Momenanzadeh et al. [4] aimed to compare pre-service teachers’ TPACK perceptions in Iran and Oman using online questionnaires. The findings revealed that PSEFLTs generally had high perceptions of their TPACK, but Iranians’ perceptions were significantly higher than those of Omanians across all TPACK subdomains. Nazari et al [21] investigated the differences in perceived TPACK between Iranian novice and experienced EFL teachers and how these differences influence their professional development using surveys. The results revealed that experienced teachers scored significantly higher in PK and PCK, while novice teachers excelled in TK, TCK, TPK, and overall TPACK. Farhadi and Öztürk’s [25] study on Turkish PSEFLTs’ TPACK level and needs revealed a generally high proficiency, but also highlighted a need for further development in TK, TCK, and TPK. Sarıçoban et al.’s [27] study quantitatively assessed the TPACK of 77 preservice EFL teachers using a survey. The results indicated a generally satisfactory level of TPACK competence, but also highlighted areas where these future teachers needed further development.

In a qualitative area of inquiry, Huang et al. [28] explored preservice English teachers’ TPACK in the context of a teaching contest. The study involved interviews with three pre-service English teachers who took part in a teaching contest aiming to uncover how this experience shaped their TPACK development. The findings indicated that their TPACK was significantly enhanced through observing role models, engaging in instructional design practice, collaborating with peers, receiving expert feedback, and participating in self-reflection. In a mixed-methods study, Koşar [14] examined PSEFLTs’ self-perceived TPACK. The content analysis of the data from the telephone interviews revealed that, while the interviewees largely perceived their TPACK level to be high, they recommended enhancing the curriculum by incorporating a course focused on the use of technology in EFL teaching. Limbong et al. [29] study explored the integration of digital technology into the teaching practices of PSEFLTs in Indonesia, leveraging the TPACK framework. The research involved six pre-service teachers, gathering data through Video-Stimulated Recall (VSR) interviews, direct classroom observations, and analysis of teaching materials such as lesson plans and multimedia resources. Findings indicated that while pre-service teachers possess theoretical knowledge about technology integration, practical implementation is often hindered by infrastructural limitations.

As the review indicated, there is a dearth of qualitative research [28][14][29] specifically looking at the perceptions and practices of PSEFLTs, particularly in the Iranian context. This research gap emphasizes the need for further investigation into how Iranian PSEFLTs perceive their TPACK competency for effectively integrating technology and how they put that into practice. Therefore, to address this gap, the current study seeks to explore PSEFLTs’ perceived TPACK competencies and their actual practices for incorporating technology. It is guided by two research questions: How do PSEFLTs perceive their competencies in TPACK? And what are the actual practices of PSEFLTs in incorporating technology into their teaching?

Review of the Related Literature

TPACK and Teacher Education

The growing importance of integrating technology into teaching has given rise to the TPACK framework [14]. TPACK is a crucial framework for educators to understand how technology can enhance the teaching and learning process. In this framework, teachers' knowledge is comprised of three primary elements: content, pedagogy, and technology. Equally important in this framework are the interactions among these three knowledge areas, as represented by PCK (Pedagogical Content Knowledge), TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge), and TPACK. It emphasizes the importance of not just using technology for the sake of using it, but integrating it in a meaningful way that enhances the overall learning experience [30][12].

While pre-service teachers are often considered digital natives due to their comfort with technology and diverse digital tools, their primary focus is typically on personal learning needs. As they transit to the role of teachers, they require the development of TPACK to effectively integrate technology into their classrooms [31]. This transition, however, takes time and effort. Research by Roney et al. [32] suggests that teachers need 3-6 years of experience to fully integrate technology into their teaching. Therefore, fostering TPACK development during pre-service teacher education programs becomes crucial to ensure their readiness for effective technology integration in their future classrooms. Such programs must focus on fostering an understanding of how technology can enhance pedagogical methods and align with content goals, thus enhancing lesson engagement and accommodating diverse learning styles [33-35].

By emphasizing TPACK in teacher training, ELT education can prepare teachers to create dynamic learning experiences that not only retain student interest but also address the challenges associated with language acquisition in various contexts, including blended and online environments. Furthermore, a robust teacher education framework that nurtures TPACK competency encourages ongoing professional development, enabling teachers to remain abreast of technological advancements and educational trends [36]. Ultimately, integrating TPACK into ELT teacher education is essential, as it ensures that EFL teachers are well-prepared to positively impact student outcomes and facilitate success in a rapidly changing, technology-driven world [37]. The four-year pre-service ELT teacher education program at Farghangian University, Iran, categorizes its courses as General Knowledge (GK), PK, CK, and PCK [38]. The curriculum comprises 150 credit units and includes only three dedicated TPK courses focused on Technology-Assisted Language Teaching (I, II, and III), which are offered during the 2nd, 3rd, and 4th semesters of study. This lack of focus on TK, TCK, and TPACK represents a significant deficiency, as these areas are crucial for effective technology integration in education [39].

Studies on PSEFLTs' TPACK Development

Recent research has investigated the TPACK competencies of pre-service English as a Foreign Language Teachers (PSEFLTs), focusing on their perceptions and use of technology in language teaching. Alhamid and Mohammad-Salehi [40] conducted a correlational study involving sixty EFL teachers, who completed questionnaires on TPACK and online teaching. The findings indicated low to moderate positive correlations between teachers' attitudes toward online instruction and TPACK domains, suggesting that those with positive attitudes also viewed their TPACK favorably. Atar et al. [41] examined the TPACK levels of 182 pre-service English teachers in Turkey using the TPACK-Deep scale. The results indicated that the teachers exhibited high TPACK competence in all three dimensions, except for Ethics, where their competence was moderate. Additionally, while gender and internet usage significantly influenced the Design dimension of TPACK, no other variables had a notable impact on overall TPACK. Cengiz and Kaçar' [42] study involved nine Turkish PSEFLTs in a six-week online teaching project, focusing on theoretical and practical training in online language instruction. Results indicated that the project enhanced the participants' overall TPACK development, yet some faced difficulties in effectively integrating technology with content and pedagogy. Faden [43] examined the relationship between pre-service English teachers' perception of their TPACK and their experience of technostress during teaching internships. The study focused on 83 pre-service English teachers who were participating in teaching internships using questionnaires. The findings revealed a low correlation between these two variables, indicating a weak, but statistically significant, association between higher perceived TPACK and lower levels of technostress during the internship period. Farhadi and Öztürk's [25] study on the TPACK levels and needs of Turkish PSEFLTs found that participants demonstrated a relatively high proficiency in TPACK. However, the results also indicated a need for further support in developing their TK, TCK, and TPK.

Within the body of research on TPACK in the Iranian context, particularly in ELT, Mansouri Qadikolaei et al. [20] investigated the level of TPACK among Iranian EFL teachers in relation to their educational background and teaching experience. The findings indicated that there were no significant differences in the scores of TK, CK, PK, PCK, TPK, and TPACK among participants at various educational levels. However, MA participants performed better than BA participants in terms of TCK scores. Additionally, the results revealed that participants with more experience achieved higher scores in PK, PCK, and TPACK compared to those with less experience. Maghsoudi' [44] study aimed at describing a causal model of variables influencing PSEFLTs' TPACK. The findings indicated that there were strong positive associations between the different aspects of TPACK. Furthermore, it was observed that both CK and PK had a direct influence on TPACK, while TK did not. Additionally, it was discovered that CK had the largest overall effect on TPACK, while PCK had the smallest effect out of all the variables measured. Momenanzadeh et al. [4] investigated differences in TPACK perceptions among preservice EFL teachers in Iran and Oman, while also exploring potential gender gaps in these perceptions. Using a quantitative design, data were collected through online questionnaires administered to pre-service teachers in both countries. The results indicated that generally preservice EFL teachers held high perceptions of their TPACK; however, Iranians demonstrated significantly higher TPACK perceptions than their Omani counterparts across all subdomains. Additionally, the study found no significant differences in TPACK perceptions based on gender in Oman, Iran, or among all participants collectively, regardless of nationality. Najjar et al. 's [15] study aimed to investigate the current state of Iranian EFL teachers' TPACK literacy, assess the impact of TPACK literacy development on their teaching practices, and explore how their perceptions of TPACK evolved through a targeted intervention. To achieve this, 15 teachers participated in TPACK workshops that utilized a learning by doing approach based on the TPACK framework. Chi-square analysis revealed statistically significant improvements in the participants' TPACK literacy following the workshops. Furthermore, the study observed a positive shift in participants' perceptions of TPACK literacy as a result of their engagement in the workshops.

In the qualitative research strand, there is a notable dearth of research focusing on the perspectives and actual practices of PSEFLTs, particularly within the Iranian context. Huang et al. [28] conducted a qualitative study examining the development of TPACK among pre-service English teachers within the context of a teaching competition. The research involved interviews with three pre-service English teachers who participated in this competitive event, aiming to understand how the contest influenced their TPACK growth. The findings revealed that their TPACK was significantly enhanced through various activities, including observing role models, engaging in instructional design practices, collaborating with peers, receiving feedback from experts, and participating in self-reflection. These experiences not only deepened their understanding of technology integration but also fostered a supportive learning environment that encouraged professional growth. Koşar [14] investigated the self-perceived TPACK of PSEFLTs. The findings revealed that while the participants generally rated their TPACK levels as high, they also identified a need for curriculum enhancement. Specifically, they recommended the inclusion of a dedicated course focused on the effective use of technology in EFL teaching, recognizing that structured learning in this area could further bolster their preparedness for the classroom. Limbong et al. [29] investigated the integration of digital technology in the teaching practices of PSEFLTs in Indonesia using the TPACK framework. The study involved six pre-service teachers and utilized Video-Stimulated Recall (VSR) interviews, classroom observations, and analyses of teaching materials. Findings revealed that while the teachers had a strong theoretical understanding of technology integration, their practical implementation was often limited by infrastructural challenges. This underscores the necessity for supportive environments and resources to enhance the effective use of technology in education.

The current study stands out by focusing on the qualitative exploration of Semnan Farhangian University PSEFLTs' perspectives on their TPACK competencies, as well as their actual practices, using interview and observation data collection instruments. This approach emphasizes an in-depth understanding of their experiences, challenges, and approaches to using technology in their teaching. The study goes beyond simply asking teachers about their TPACK perceptions and delves into their actual abilities and skills in using technology effectively in the EFL classrooms. This is a vital aspect often neglected in previous research.

Method

Participants

The study included ten pre-service teachers, comprising six females and four males, all in their final year of an ELT teacher education program, selected through purposive sampling. The researcher focused on last-year students for two main reasons: their accumulated experience and knowledge provide valuable insights into TPACK development, and assessing their TPACK levels can inform their readiness for real-world teaching and guide curriculum development to better prepare future EFL teachers for technology-driven classrooms (see Table 1).

Table 1: Participants' demographic information

Pseudonym	Age	Gender	Degree	Education
Anahita	23	Female	BA Students	English Language Teaching
Arman	22	Male		
Farhad	24	Male		
Fatima	22	Female		
Golnaz	23	Female		
Kiyn	21	Male		
Neda	25	Female		
Parisa	23	Female		
Ramin	22	Male		
Shirin	22	Female		

*BA: Bachelor of Art

Instruments

Semi-Structured Interviews

To gain insights into the PSEFLTs' perceptions regarding their TPACK competencies, semi-structured interviews were conducted. These interviews provided the researcher with the opportunity to delve deeper into specific variables and obtain detailed descriptions. Glesne [45] emphasizes the importance of interview data, arguing that interviews allow researchers to uncover valuable insights that may have been overlooked. Furthermore, interviews enable researchers to explore alternative interpretations and explanations for the observed phenomena.

The interviews employed open-ended questions and prompts designed to explore PSEFLTs' perceptions of their TPACK competencies at Semnan Farhangian University, Iran (see Appendix A). The questions were formulated based on a review of the literature on TPACK, including studies by Cengiz and Kaçar [42], Koehler et al. [5], Koşar [14], Cheng and Xie [46], and Sarıçoban et al. [27], as well as consulting experts in the field. In this study, the EFL teacher educators acted as peer debriefers [47], which contributed to enhancing the validity of the research. Their feedback indicated that the questions effectively elicited responses relevant to the research questions. To enhance the study's credibility, a pilot study was conducted with a small group of PSEFLTs who shared similar characteristics with the main participants. This pilot aimed to test the interview questions for relevance, clarity, and comprehensiveness. Feedback from the pilot participants led to revisions, including rewording some questions and adding a follow-up question to improve the interview instrument.

Individual interviews were then scheduled and conducted with the PSEFLTs who agreed to participate. The interviews took place in a comfortable and private meeting room. Informed consent was obtained from each participant before starting the interview. Each interview lasted around 90 minutes. Throughout the data collection procedure, ongoing communication and support were provided to the participants, addressing any concerns or questions they may have had. Regular reflection on the data collection process enabled adjustments to be made to improve the quality and rigor of the research.

Observations

Following a review of the relevant literature [14][28,29], an observation checklist was developed, grounded in the TPACK framework (see Appendix B). The checklist underwent a thorough validation process involving expert reviews from experienced educators and researchers in English Language Teaching (ELT) and technology integration, ensuring it accurately represented the key dimensions of the TPACK framework. A pilot observation with a small group of PSEFLTs provided further refinements based on their feedback. These observations complemented qualitative data from semi-structured interviews by offering real-world context, validating participants' self-reported experiences, and identifying specific behavioral patterns and challenges encountered by PSEFLTs in implementing TPACK in their lessons.

Procedure

To address the research questions guiding the study, the researcher chose to use a qualitative case study design. According to Creswell and Poth [48], this design allows researchers to focus on either a single case or multiple cases, providing a comprehensive and detailed description and explanation within a specific context. The study employed semi-structured interviews to gather in-depth insights from a purposive sample of PSEFLTs at Semnan Farhangian University regarding their competencies in TPACK. Farhangian University is a renowned institution for teacher education, and its ELT program aims to equip PSEFLTs with the necessary knowledge and skills to become effective language teachers. These future teachers were also observed during their practice teaching sessions. The observations provided a comprehensive understanding of how they leverage their abilities to integrate technology into their teaching practice. By triangulating the observational data with interview insights, the study aimed to create a comprehensive understanding of pre-service teachers' TPACK competencies, enhancing the credibility of the findings.

Ethical approval was obtained from the relevant ethics committee to ensure the research was conducted in an ethical manner and protected the rights and confidentiality of the participants. Participants were recruited through invitations that provided detailed information about the research purpose, objectives, time commitment, and potential benefits of participation. To ensure the confidentiality of the participants, pseudonyms were employed when presenting the results of the study.

Individual, in-person interviews were conducted with ten PSEFLTs. All of the interviews were conducted by the researcher from September 2023 to November 2023. The interviews were recorded with the participants' permission, using appropriate recording equipment. The use of participants' own words in qualitative research would increase the interpretation of data, as Wallestad [49] points out. Detailed notes were also taken during the interviews to supplement the recorded data. The recorded interviews were transcribed verbatim, capturing the participants' responses accurately. Qualitative data analysis techniques, such as thematic analysis, were used to analyze the transcribed data. Recurring patterns, themes, and categories related to the participants' competencies in TPACK were identified. The findings were interpreted to answer the research questions and draw meaningful conclusions.

The participants then received a pre-observation briefing on the study's purpose and ethical considerations. Observations were conducted in English classrooms where PSEFLTs were engaged in their practice teaching. Settings varied in terms of class size, students' demographics, and technology availability to capture a diverse range of teaching scenarios. Observations were carried out over multiple sessions across different teaching environments, using a structured form to ensure consistency and objectivity in data collection. Detailed field notes were also taken to capture nuanced observations. The observer conducted sessions unobtrusively, allowing for naturalistic data collection over 60 to 90 minutes. The observational data were analyzed by coding the notes, categorizing behaviors, and identifying patterns related to TPACK competency. The researcher looked for examples of successful integration of technology, effective pedagogical practices, and coherent content delivery in the observed teaching practices. The observations took place after the interviews.

Six stages were followed to analyze the interview and observation data, guided by the TPACK framework [5,10]. First, the data were read multiple times to familiarize the researcher with the responses. Following this, initial codes were generated through an iterative analysis of the transcripts. The researcher then grouped these codes to form broader themes. Afterward, the extracted macro-themes were reviewed and refined before finalizing the report. Each theme was given a specific name and label. Finally, a comprehensive report detailing the overall findings was prepared. To ensure trustworthiness in this qualitative study, several measures were implemented. First, member-checking involved participants scrutinizing the extracted themes and findings. Second, an expert coder was invited to analyze the data, and inter-coder reliability was assessed using Cohen's Kappa Coefficient, yielding a satisfactory index (r = 0.80). To enhance transferability and confirmability, a detailed description of participants, context, instruments, data collection, and analysis was provided. Finally, acknowledging the researcher's positionality, both data collection and analysis were conducted by the same researcher.

Results and Discussion

The findings of the present study are classified based on PSEFLTs' perspectives and practices regarding their TK, CK, PK as well as the intersections among these areas, namely TCK, TPK, PCK, and TPACK, which will be presented respectively.

PSEFLTs' Perspectives and Practices regarding their TK

The following table (Table 2) provides an overview highlighting the primary interview findings related to PSEFLTs' TK.

Findings indicate that nine out of ten PSEFLTs at Semnan Farhangian University perceived their level of TK to be moderate. They justified this by stating that many students are tech-savvy and can assist teachers with troubleshooting software or hardware problems, while there is one technology technician at every school. As an example, Kiyan mentioned,

> *… I use technology in my lessons, but I wouldn't say I fully utilize all available tools...To be honest, I rely on my students to help troubleshoot any technical issues that arise.*

Interestingly, Anahita diverged from this general perception, identifying herself as a 'high-tech person' due to her personal interests in technology. She argued,

> *I am adept at using technology, both in general and specifically for language teaching. This proficiency is largely due to my personal interest in English, as well as my commitment to exploring and staying updated on the latest educational technologies.*

Table 2: Key interview findings on TK of PSEFLTs

Theme	Sub-Theme	Description	Frequency %	Evidence from Text
PSEFLTs' TK	Level of TK	PSEFLTs at Semnan Farhangian University possess a moderate level of TK.	90%	I wouldn't say I'm a tech expert… I rely on my students to help troubleshoot any technical issues that arise.
	Familiarity with Basic Tools	They demonstrated familiarity with basic tools and applications used in language teaching.	100%	I often use PowerPoint for my presentations and sometimes incorporate online videos.
	Limited Knowledge of Advanced Tools and Emerging Trends	Their knowledge of advanced technological tools and emerging trends in educational technology appeared to be limited.	90%	The use of virtual reality in language learning offers exciting immersive experiences. However, the lack of training on effective implementation makes it overwhelming for me.
	Professional Development for Technology Integration	The PSEFLTs acknowledge their need for further training in technology integration and best practices.	100%	Hands-on workshops and online courses would help deepen our understanding and proficiency in using these tools effectively.

All ten participants demonstrated familiarity with basic tools and applications commonly used in language teaching, such as PowerPoint, Microsoft Word, interactive whiteboards, language learning software, and online resources. For instance, Fatima argued,

> *I primarily use tools like PowerPoint for presentations and Microsoft Word for creating handouts and lesson plans. I find that these tools are easy to use and help me organize my lessons effectively.*

Parisa remarked,

> *I use Duolingo and Quizlet. What I appreciate is the personalized feedback; students can see where they need to improve right away. It's been beneficial, especially for those who learn differently.*

However, the PSEFLTs' knowledge of more advanced technological tools and emerging trends in educational technology appeared to be limited. Nine participants reiterated that they had not received sufficient training or exposure to innovative technologies, stating that their coursework primarily focused on basic applications. For instance, Neda stated,

> *I feel like I only know the basics. I have used tools like PowerPoint and some language learning software, but when it comes to things like virtual or augmented reality, I just don't have any experience.*

All of the participants expressed the need for additional training to become familiar with the latest technologies in the field of ELT. They indicated that while they are comfortable using basic tools, they recognize the importance of staying updated with emerging technologies and educational trends that could enhance their teaching practices and improve student engagement. This desire for professional development reflects their commitment to providing high-quality language instruction in an increasingly digital learning environment. For instance, Farhad maintained,

> *Hands-on workshops and online courses would help deepen our understanding*

and proficiency in using these tools effectively.

While the majority of the PSEFLTs included basic technologies in their lesson plans, observations revealed a limited use of technology. For example, in one lesson, Shirin used a PowerPoint presentation to introduce vocabulary, but then reverted to traditional exercises from a textbook for practice. In another scenario, although the lesson plan included using an online vocabulary quiz, it was not implemented, and Fatima opted for a traditional paper-based quiz instead. Or, Ramin appeared hesitant to use the interactive whiteboard for collaborative activities and preferred to conduct the lesson individually at the front of the class. This indicates a need for further development in their TK to effectively leverage technology for enhancing EFL learning. Only Anahita was able to use online collaboration platforms and virtual reality applications effectively.

To conclude, participants assessed their technological knowledge (TK) as moderate, indicating familiarity with basic tools like word processors and presentation software. This self-assessment reflects an awareness of the changing educational technology landscape and the need for ongoing professional development. It suggests a gap between their current skills and the advanced technological abilities required to create interactive learning experiences. Their moderate TK may lead them to rely on familiar tools rather than exploring innovative technologies that could boost student engagement. Contributing factors to this moderate level include insufficient integration of technology in ELT teacher education programs, challenges in keeping up with rapid technological advancements, limited access to resources, and a lack of practical training. Pre-service teachers expressed a desire for more hands-on training and guidance in integrating technology into language learning, emphasizing the need for support to enhance their TPACK competencies.

The findings of the present study are in line with that of Sánchez et al. [16] who conducted an analysis of TPACK implementation in Spanish primary EFL teacher education. They concluded that TPACK integration in that context was moderate, underscoring the need for a more thorough integration of technology in EFL teacher training programs. The results are also similar with Hadidi et al.'s [50] findings indicating that Iranian EFL teachers possess a limited understanding of technology and are not adequately equipped to effectively incorporate technology into their teaching practices. Similarly, Fathi and Yousefifard [22] reiterated that Iranian teachers should enhance their understanding and proficiency in pedagogical technology and content technology. However, the findings of this study stand in contrast to those reported by Cengiz and Kaçar [42] and Koşar [14], where participants generally assessed their levels of TPACK as high in almost all TPACK dimensions. While Cengiz and Kaçar, along with Koşar, indicated a perception of strong competence in integrating technology into pedagogy and content, this study reveals a moderate level of TK competence among participants. This discrepancy raises important questions about the self-assessment practices of participants in different educational contexts and suggests that while individuals may feel confident in their TPACK abilities, actual implementation may vary significantly. Further investigation into the factors influencing this perception could provide valuable insights into the effectiveness of teacher training programs in fostering robust TPACK integration.

PSEFLTs’ Perspectives and Practices regarding their CK, PCK, and TCK

The following table (Table 3) provides an overview of key findings from interviews concerning the CK, PCK and TCK of PSEFLTs.

The interview findings indicated that nine out of ten PSEFLTs possess a strong foundation in the fundamental CK required for effective English language teaching. This includes expertise in grammar, vocabulary, language skills, assessment methods, and the strategies and techniques for delivering these elements.

In terms of grammar, nine participants reiterated that they had proficiency in identifying and explaining various grammatical structures, which is crucial for helping learners grasp the complexities of the English language. Their knowledge extended beyond mere rules and included an awareness of contextual application and common grammatical pitfalls that language learners often encounter. For instance, Anahita stated,

> *Grammar isn’t just about memorizing rules; it’s about application. I focus on common challenges, like subject-verb agreement and tense usage, because addressing these can significantly help my students’ understanding of the language.*

When it came to vocabulary, nine PSEFLTs articulated an understanding of both the breadth and depth required to effectively teach vocabulary. They recognized the importance of teaching not just individual words but also phrases and the nuances of meaning that can change depending on context. This insight reflects their preparedness to equip students with the lexical resources needed for effective communication. As an example, Golnaz discussed,

> *… I focus on phrases and context because meaning can shift based on how words are used. For instance, teaching the phrase ‘kick the bucket’ helps students understand idiomatic expressions, which is essential for real communication.*

Additionally, the interviews revealed that nine candidates possessed a solid grounding in the four primary language skills: listening, speaking, reading, and writing. They articulated various strategies for integrating these skills into their lesson plans, recognizing that an integrated approach is essential for language acquisition. Their awareness of the interplay between these skills suggests a readiness to design comprehensive learning experiences tailored to diverse student needs. To give an example, Neda asserted,

Table 3: Key interview findings on CK and TCK of PSEFLTs

Theme	Sub-Theme	Description	Frequency %	Evidence from Text
PSEFLTs’ CK, PCK, and TCK	Strong Foundation in CK	They possessed a solid understanding of grammar, vocabulary, language skills, and language assessment.	90%	I have gained a deep understanding of English grammar, syntax, and vocabulary, equipping me with the skills needed to teach these elements effectively.
	Solid Foundation in PCK	They knew the strategies and techniques for teaching English effectively to learners.	90%	I often use interactive activities such as role-playing to teach vocabulary in context.
	Technology Gap in Educational Practices	They felt unprepared to fully integrate technology while delivering content.	90%	I know some tools, but during lessons, I often struggle to make the most of them and worry I’m not engaging my students.

After completing a reading assignment, I organize group discussions where they can express their thoughts and opinions. This approach not only improves their comprehension of the text but also boosts their speaking confidence.

However, one participant, i.e. Kiyan believed that since he has not been interested in ELT from the very first day, he often struggles to find motivation in his coursework. He expressed that this lack of enthusiasm affects his engagement with the subject matter, making it challenging for him to fully invest in learning the necessary skills and technologies required for effective language teaching. Kiyan indicated that he feels disconnected from the material and worries that his limited interest might hinder his ability to effectively teach English in the future. As a result, he recognized the need for a more compelling approach to his studies that could spark his interest and foster a deeper connection to the field of ELT.

The interview findings revealed that eight out of ten PSEFLTs possess reasonable assessment expertise, which are crucial for effective language teaching. They recognized the importance of formative assessments, such as quizzes and class activities, to monitor progress and provide ongoing feedback. Additionally, the candidates emphasized their commitment to utilizing summative assessments, like tests and projects, to gauge overall proficiency at the end of instructional units. For instance, Shirin reiterated,

I use quick quizzes and group activities to gauge understanding in real-time. It helps me adjust my teaching on the spot. In addition, I always incorporate summative assessments at the end of a unit to evaluate overall progress.

However, two participants expressed concerns regarding their ability to develop and implement diverse assessment methods effectively. For instance, Neda admitted,

I struggle with creating assessments that truly reflect my students' understanding. Sometimes, I rely too heavily on traditional tests and worry that I'm missing out on important aspects of their learning.

While all participants recognized the importance of incorporating technology into classroom content delivery, nine admitted to lacking specific TCK that would enable them to seamlessly integrate tech tools with their language instruction. For instance, Fatima stated,

I'm comfortable with the content, but I find it challenging to connect that content with appropriate technological resources.

During the observation of the PSEFLTs, it was evident that they displayed a robust foundation in CK and PCK. Their lessons were structured and well-paced, ensuring that students had ample time to grasp the concepts without feeling rushed or overwhelmed. They confidently led grammar lessons, providing students with clear explanations of verb tenses, sentence structures, and other key grammatical concepts. For example, during her lesson on present perfect continuous, Parisa, one of the PSEFLTs, effectively conveyed the concept using clear explanations, real-life examples, and a fun game. She started by explaining the form and usage of the tense using a timeline visual, then provided examples of how it's used to talk about ongoing activities that started in the past. She then engaged the students in a game where they had to guess which activities were still ongoing. This demonstrated her understanding of how to make grammar concepts relatable and engaging for students.

PSEFLTs supplemented explanations by guiding students through targeted practice activities, such as error correction exercises, transformation drills, and sentence combining tasks. These practice activities allowed students to actively apply the grammatical rules and receive immediate feedback to reinforce their understanding. As an example, while teaching phrasal verbs, Ramin began by eliciting common phrasal verbs from the students themselves, creating an immediate connection to their own experiences. He then transitioned into a fun game where students had to match phrasal verbs with their definitions, using visuals and real-life scenarios. This interactive approach kept the students actively involved and fostered a positive learning environment. By tapping into their existing knowledge and incorporating playful elements, Ramin made the lesson both enjoyable and effective.

Additionally, PSEFLTs implemented effective vocabulary acquisition techniques, such as using visual aids, contextual clues, and word mapping strategies to help students build their lexical repertoire. For instance, during a lesson on weather vocabulary, Golnaz used flashcards with images of different types of weather (e.g., sunny, rainy, snowy) alongside their corresponding words. This allowed students to associate the word with a visual representation, aiding their understanding and memorization.

PSEFLTs created interactive language learning activities such as role-plays, discussions, and task-based exercises to enhance students' communicative skills. Their subject knowledge was demonstrated through their ability to answer student questions and provide relevant examples. They employed diverse instructional strategies in their lesson plans to meet various student needs and promote language proficiency. For instance, in a lesson on 'travel', Farhad designed a task where students planned a fictional trip, requiring them to use English for communication and decision-making. His expertise was evident as he addressed questions about cultural norms and transportation, offering valuable insights to aid student success.

Observations revealed that teachers' limited familiarity with technological tools impeded their ability to create dynamic and interactive learning experiences. Although they were eager to incorporate technology, their lack of expertise sometimes resulted in logistical challenges. For instance, during a lesson on location descriptions, Ramin struggled with Google Earth due to his inexperience, leading to technical difficulties that disrupted the flow of the lesson and caused students to lose focus. Additionally, the preservice teachers' limitations in TCK restricted their ability to address diverse learning styles and engage students innovatively. To give an example, in a vocabulary acquisition lesson, Neda attempted to use Quizlet to cater to different learning styles. However, due to her limited understanding of the app's features, she was unable to customize the flashcards with multimedia elements such as images and audio, which could have benefited visual and auditory learners. As a result, the activity relied solely on text-based flashcards, failing to engage kinesthetic learners who might have benefited from interactive elements. Their unfamiliarity with technological tools also hindered their capacity to provide timely, personalized feedback. For example, Shirin's attempt to use Kahoot for assessing grammar understanding fell short because she relied on default settings, resulting in simplistic multiple-choice quizzes that failed to address student misconceptions. This limited assessment approach negatively affected both her teaching effectiveness and the students' language development.

Overall, PSEFLTs often face limitations in TCK primarily due to a lack of targeted training in the integration of technology within their subject area. ELT Teacher education programs frequently emphasize traditional language teaching methodologies and CK without adequately addressing how to leverage technology effectively for instructional purposes. Consequently, PSEFLTs might graduate with a strong understanding of English language content and delivery techniques, yet they may not have a sufficient grasp of how to effectively utilize digital tools to enhance that content. Additionally, the rapid pace of technological advancement can render training and resources quickly outdated, making it challenging for educators to stay current. This gap in TCK can inhibit their ability to create engaging, technology-enhanced learning experiences for their future students, ultimately impacting their effectiveness in the classroom.

The findings of this study are congruent with those of Dinçer et al. [24]. In their study, participants rated their CK and PCK very high, with an average score of 8.47. They felt confident in their English reading comprehension, while they expressed a slight hesitation in their ability to articulate ideas and feelings in English. However, TCK showed lower competence levels, with scores under the survey's mean score. The findings of this study also align with those of Archambault and Crippen [51] and Valtonen et al. [52], where participants identified TCK as the most challenging area. They expressed less confidence in their technology-related skills and in their ability to effectively use technology to deliver content to students. However, the findings of this study contrast with those of Koşar [14], where participants demonstrated confidence in using various technological tools and platforms effectively, indicating comfort in integrating technology into their teaching. However, they recognized a need for additional support in mastering content specific to English language instruction.

PSEFLTs' Perspectives and Practices regarding their PK, TPK, and TPACK

Table 4 below summarizes the key findings from interviews related to the PK, TPK, and TPACK of PSEFLTs.

Table 4: Key interview findings on PK, TPK, and TPACK of PSEFLTs

Theme	Sub-Theme	Description	Frequency %	Evidence from Text
PSEFLTs' PK, TPK, and TPACK	Strong Foundation in PK	The PSEFLTs exhibited a solid grasp of various pedagogical approaches and strategies crucial for effective teaching.	80%	I always prioritize student-centered activities in my lessons because they encourage learners to take ownership of their learning.
	Technology Gap in Educational Practices	They struggled to translate their PK into practical, effective implementations with technology.	90%	Although I understand the advantages of using technology in teaching, I find it challenging to effectively integrate these tools into my pedagogy, often reverting to traditional methods.

Eight out of ten PSEFLTs demonstrated a solid understanding of pedagogical approaches and strategies. They were aware of the importance of student-centered learning, task-based instruction, and communicative language teaching. As an example, Neda mentioned,

I developed a solid understanding of diverse pedagogical approaches, emphasizing student-centered learning. I have also been introduced to different instructional techniques, such as scaffolding and guided practice, to support students' language development.

However, Kiyan mentioned,

I've been taught concepts like task-based instruction and the flipped classroom, but I can't say I fully grasp how to apply them. I sometimes feel overwhelmed and end up going back to what I know best, just delivering content.

While the PSEFLTs grasp the theoretical principles of teaching, they often struggle to translate this knowledge into practical technology-based applications, as nine of the PSEFLTs highlighted. As an example, Arman argued,

I get the theory of digital storytelling, but putting it into practice is a whole different ballgame. I can't seem to find the right tools, and I'm lost with all the technical stuff!

Observations of the PSEFLTs highlighted their strong understanding of various pedagogical approaches and strategies. They effectively incorporated methods such as collaborative and task-based learning into their lesson plans, demonstrating an ability to cater to diverse learning styles through differentiated instruction and scaffolding techniques. Their classroom management skills, including clear expectations and positive reinforcement, kept students engaged. For example, in Farhad's class, he established a conducive learning environment by outlining lesson objectives and starting with an engaging icebreaker activity that encouraged students to introduce themselves in English. He actively monitored participation, providing support to shy students like Reza through gentle prompts and positive reinforcement. The lesson concluded with a reflective session that valued every student's input, fostering a respectful and inclusive atmosphere.

However, the PSEFLTs demonstrated a limited ability to translate their knowledge of pedagogical approaches into practical implementation with technology, particularly advanced tools. For instance, Fatima struggled to integrate multimedia elements into her lesson and opted for traditional presentation software instead of utilizing virtual reality, missing opportunities for more immersive learning experiences. Similarly, Arman faced challenges in setting up and managing Google Classroom for project-based learning activities, which hindered his ability to facilitate meaningful collaboration and communication among students.

To conclude, preservice teachers face challenges in applying their PK to technology-enhanced teaching, which can be linked to the TPACK framework. TPACK emphasizes the integration of CK, PK, and TK. A significant gap in TK arises from inadequate training and exposure to technology during pre-service programs, limiting their ability to effectively integrate technology into their teaching. The lack of hands-on experience with digital tools hinders their connection between theory and practice, resulting in less engaging learning environments. Additionally, limited access to reliable technology in training institutions and future teaching contexts restricts opportunities for preservice teachers to develop their technological skills. The rapid evolution of technology and educational software further complicates their ability to stay updated and adapt their teaching strategies. This situation underscores the need for a comprehensive TPACK framework that fosters the development of all three knowledge areas, enabling preservice teachers to successfully integrate technology into their teaching practices.

The findings of this study align with those of Akyuz [53] and Farhadi and Öztürk's [25] research on the TPACK levels of Turkish PSEFLTs, indicating a need for additional support in enhancing their TK, TCK, and TPK. However, the findings of the present study contrast with those of Sarıçoban et al. [27]. In their study, the participants surveyed indicated a high level of confidence in their TPK. They reported feeling proficient in using multimedia to support language learning, designing learning materials using technology, deciding when technology is beneficial for specific English standards, and managing the classroom environment while utilizing technology.

This study has several limitations that should be considered when interpreting its findings. The results may be specific to the PSEFLTs at Farhangian University in Iran and may not represent the broader population across the country, thus caution is advised in generalizing the findings. The focus on a single institution limits the applicability of the results, and conducting similar studies in various institutions or locations could enhance understanding of PSEFLTs' competencies in TPACK. Additionally, longitudinal studies tracking the development of these competencies over time would provide valuable insights into how TPACK evolves throughout teacher training.

The findings of this study have important implications for teacher education programs. While many programs worldwide include courses on teaching with technology [54,55], they often overlook the specific contexts that affect participants' engagement with technology. By understanding the factors that influence technology use, teacher educators can make necessary adjustments to their programs. The study's insights can help design more effective teacher training that integrates technology with pedagogical content knowledge. Additionally, these findings can guide the development of tailored professional development opportunities for PSEFLTs, addressing specific challenges and enhancing their understanding of TPACK. Universities can use the identified gaps in TPACK knowledge to inform investments in technological resources and training, ensuring that new teachers are well-equipped for modern language education. Overall, the study highlights the essential connection between technology and pedagogy in effective language teaching, advocating for a comprehensive approach to preparing future EFL teachers.

Future research could expand on the findings of this study by conducting interviews with professors in the ELT department and technology instructors at the university, which will help improve understanding of the conditions affecting TPACK development. Additionally, comparing the TPACK competencies of PSEFLTs with those of experienced EFL teachers would help identify any gaps or differences in their TPACK. This comparative analysis would contribute to a better understanding of how TPACK is developed and enhanced over time, providing valuable insights into effective practices for integrating technology in language education. Finally, investigating the impact of the PSEFLTs' competencies in TPACK on student learning outcomes can provide valuable insights into the effectiveness of technology integration in language classrooms. This could involve examining students' language proficiency, engagement, and motivation when technology is effectively utilized by their teachers.

Conclusions

This study aimed to investigate the perceived TPACK of PSEFLTs as well as their actual teaching practices. The findings indicated that while PSEFLTs demonstrated a solid foundation in CK, PK, and PCK, their TK, TCK, TPK, and TPACK competencies appeared to be limited. To improve the development of TPACK among PSEFLTs, it is recommended to provide more hands-on training, practical experiences and promoting collaboration and networking with various educational technologies. Ongoing professional development opportunities should be made available to pre-service teachers to enhance their TPACK competence. Additionally, integrating TPACK principles across all courses in the curriculum would help reinforce the importance of technology integration in ELT. By continuously exploring and advancing our understanding of TPACK in ELT, we can ensure that our educators are equipped with the knowledge and skills to navigate the digital landscape of education successfully.

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Conflicts of Interest

The author has no conflicts of interest.

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Appendix A

Interview Questions

Participant Name:
Date of Interview:
Interviewer Name:
Location:

1. How would you rate your level of technological knowledge in relation to your teaching practices? Would you describe it as basic, moderate, or advanced? Why?
2. To what extent are you familiar with basic technological tools that can be used in your classroom?
3. How confident do you feel in your knowledge of advanced tools and emerging trends in educational technology?
4. What types of professional development opportunities do you believe would best support your integration of technology into your teaching?
5. How confident do you feel in your understanding of grammar, vocabulary, language skills, and language assessment?
6. How well do you believe you understand various pedagogical approaches and strategies that are essential for effective teaching?
7. To what extent do you believe you are prepared to integrate technology effectively while delivering content in your lessons?
8. What challenges do you face in applying your pedagogical knowledge to effectively implement technology in your teaching practice?

Appendix B

Observation Checklist for TPACK Competencies

Observer Information
Observer Name:
Date:
Class Session:
Instructor Name:
TPACK Components (Please mark as Observed/Not Observed (O/NO)

TPACK Component	Criteria/ Indicators	O / NO	Comments
Content Knowledge (CK)	Demonstrates strong knowledge of English language content		
	Explains content concepts clearly and accurately		
	Uses authentic materials and resources		
Pedagogical Knowledge (PK)	Utilizes various teaching strategies and		

TPACK Component	Criteria/ Indicators	O / NO	Comments
	techniques suited to EFL contexts		
	Encourages student interaction and engagement		
	Differentiates instruction based on student needs		
	Manages classroom effectively and fosters a conducive learning environment.		
Technological Knowledge (TK)	Demonstrates proficiency in using technology for teaching and learning.		
	Selects appropriate technological tools and resources to enhance instruction.		
	Integrates technology seamlessly into lesson plans and activities.		
Technological Content Knowledge (TCK)	Integrates technology directly related to specific language content		
	Chooses appropriate tech tools for teaching language		
	Utilizes software/tools to facilitate language practice (e.g., online quizzes, apps)		
Technological Pedagogical	Designs tech-enhanced		

TPACK Component	Criteria/ Indicators	O / NO	Comments
Knowledge (TPK)	lessons that promote active learning		
	Demonstrates effective management of technology in the classroom		
	Guides students in using technology collaboratively		
Pedagogical Content Knowledge (PCK)	Adapts teaching strategies for specific language content		
	Integrates culture and real-life context into language lessons		
	Employs formative assessments to gauge understanding		
Overall TPACK Integration	Demonstrates a strong understanding of how technology can be used to enhance the		
	teaching and learning of English language content.		
	Uses technology to engage learners, provide feedback, and personalize learning experiences.		
	Effectively integrates technology to create meaningful and engaging learning experiences for EFL learners.		
	Encourages critical thinking and problem-solving through tech integration		

Additional Observations
Strengths:
Areas for Improvement:

Conclusion
Overall Impression of TPACK Competency:
Comments

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ORIGINAL RESEARCH PAPER

The Effect of Badges in gamification Point System on 1st Grade Students' Reading, Writing Skills, and Academic Engagement

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ABSTRACT

Background and Objectives: Learning reading and writing skills in the first grade is crucial and fundamental. It has always been considered highly important for students to learn these skills at an early age. By learning to read in elementary school, students can accurately and comprehensively read various texts, including words, sentences, and simple texts. Strengthening their reading skills enables students to understand and benefit from the information available in books, newspapers, magazines, and other resources, which is essential for effective learning and progress in different subjects. Moreover, learning writing skills is also of great importance in the first grade. With this skill, students can express their thoughts, ideas, and experiences fully and accurately. They can arrange sentences in a logical order, use correct grammar rules, and form paragraphs correctly. This fundamental skill is crucial for written communication in the future and helps students develop strong analytical skills, creativity, and oral communication abilities. Engaging students in the learning process is one of the major challenges faced by teachers. Therefore, the use of an engaging learning method has become a concern for teachers in the field of teaching and learning. This study aimed to investigate the impact of gamification with badges on reading and writing skills as well as academic engagement among first-grade elementary school students.

Materials and Methods: The research population consisted of all female first-grade students in Qazvin province during the academic year 2020-2021. A cluster sampling method was used to select the sample from different classes across the city. The sample size included three groups of 25 students each, divided into two experimental groups (gamification with badges and gamification without badges) and one control group. The research design employed a pretest-posttest design with a control group. The research instruments included researcher-developed reading and writing skill tests and the Rio Academic Engagement Questionnaire. The reliability of each measure was calculated using Cronbach's alpha. Descriptive statistics were used to analyze the data, including means and standard deviations, while inferential statistics included Analysis of Covariance and Tukey's post hoc test using SPSS software.

Findings: The results of the Analysis of Covariance indicated that the use of gamification had a significant effect on reading skills ($F = 6.166$, $p< 0.003$) and writing skills ($F = 4.88$, $p< 0.010$), as well as academic engagement (behavioral: $F = 134.462$, $p < 0.000$; emotional: $F = 43.546$, $p< 0.000$; cognitive: $F = 348.598$, $p< 0.000$; and agentic: $F = 349.853$, $p< 0.000$). Furthermore, Tukey's post hoc test revealed that the gamification with badges group outperformed the gamification without badges group in three subscales of the academic engagement (behavioral, agentic, and cognitive).

Conclusions: The findings of this study demonstrated that the use of gamification had a positive impact on reading and writing skills as well as academic engagement among elementary school students. Some recommendations include utilizing gamification strategies to create interactive, engaging, and lively learning environments, designing gamified learning environments to enhance motivation, participation, collaboration, and engagement, and exploring the effects of gamification (e.g., leaderboard) on increasing students' teamwork abilities.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
43	1	17

مقاله پژوهشی

تاثیر نشان‌ها در سیستم امتیازدهی بازیوارسازی بر یادگیری مهارت خواندن و نوشتن و درگیری تحصیلی دانش‌آموزان پایه اول ابتدایی

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چکیده

پیشـینه و اهداف: یادگیری مهارت خواندن و نوشـتن در پایه اول ابتدایی همواره از اهمیت بالایی برخوردار بوده اســت. یادگیری مهارت خولندن به دانش‌آموزان این امکان را می‌دهد تا متون مختلف را با دقت و درک کامل بخوانند. این مهارت شــامل خولندن کلمات، جملات و متون ســاده اســت. با تقویت مهارت خولندن، دانش‌آموزان قادر خواهند بود اطلاعات موجود در کتاب‌ها، روزنامه‌ها، مجلات و سـایر منابع را به درسـتی درک کنند و از آن‌ها بهره ببرند. این مهارت مهم برای یادگیری موثر و پیشـرفت در دروس مختلف ضـروری اسـت. از سـوی دیگر مهارت نوشـتن نیز در پایه اول ابتدایی بسـیار اهمیت دارد زیرا با این مهارت، دانش‌آموزان می‌توانند اندیشــه‌ها، ایده‌ها و تجربیات خود را به صـورت کامل و صـحیح بیان کنند. آن‌ها می‌توانند جملات را به ترتیب منطقی بچینند، از قواعد گرامری صـحیح اسـتفاده کنند و پاراگراف‌ها را به درسـتی تشـکیل دهند. این مهارت اسـاسـی برای ارتباطات نوشـتاری در آینده اسـت و دانش‌آموزان را در توسـعه مهارت‌های تحلیلی، خلاقیت و ارتباطات کلامی قوی می‌کند. یکی از مسائلی که معلمان با آن روبرو هستند درگیری تحصیلی دانش آموزان در فرآیندیادگیری اســت. بنابراین اســتفاده از یک روش جذاب یادگیری به عنوان یکی از دغدغه های معلمان در حوزه فرآیندیاددهی_یادگیری می باشد. پژوهش حاضـر با هدف بررسـی تأثیر نشـان‌ها در سـیسـتم امتیازدهی بازی‌وارسازی بر یادگیری مهارت خواندن و نوشتن و درگیری‌تحصیلی دانش‌آموزان پایه اول ابتدایی انجام شده است.

روش‌ها: جامعه آماری پژوهش شـامل کلیه دانش‌آموزان دختر پایه اول ابتدایی اسـتان قزوین بود، که در سـال تحصیلی ۱۴۰۰-۱۳۹۹ مشغول به تحصیل بودند. نمونه پژوهش با روش نمونه‌گیری خوشه‌ای انتخاب و در سه گروه ۲۵ نفری به صـورت تصـادفی گمارش شـد. پس از اجرای پیش آزمون گروه آزمایش ۱ (بازی‌وارسـازی بانشـان گروه آزمایش) ۲ (بازی‌وارسازی بی‌نشـان) و گروه کنترل با روش معمول آموزش دیدند. روش پژوهش، روش آزمایشی (طرح پیش‌آزمون- پس‌آزمون با گروه کنترل) بود. ابزار پژوهش شامل آزمون‌هاییادگیری مهارت خواندن و نوشــتن محقق سـاخته و پرســشــنامه درگیری‌تحصـیلی ریو بود که پایایی هرکدام با آلفای کرونباخ محاســبه شــد. جهت تجزیه‌وتحلیل داده‌ها در بخش آمار توصــیفی میانگین، انحراف معیار و در بخش آمار استنباطی تحلیل کوواریانس و آزمون تعقیبی توکی با استفاده از نرم‌افزار اس‌پی‌اس استفاده گردید.

یافته‌ها: نتایج تحلیل کوواریانس نشان داد که استفاده از بازی‌وارسازی بر یادگیری مهارت خواندن(F= ۶/۱۶۶، sig۰/۰۰۳) و مهـارت نوشــتن (F= ۴/۸۸، sig= ۰/۰۱۰)و درگیری‌تحصــیلی (رفتـاری: F= ۱۳۴/۴۶۲، sig=۰/۰۰۰، عاملی: (F= ۳۴۹/۸۵۳، sig=۰/۰۰۰، شناختی: (F= ۳۴۸/۵۹۸، sig= ۰/۰۰۰ و عاطفی: F= ۴۳/۵۴۶، sig= ۰/۰۰۰) مؤثر بوده است، همچنین نتایج آزمون تعقیبی توکی نشان داد که گروه بازی‌وارسازی بانشان

در ۳ زیرمقیاس درگیری‌تحصیلی (رفتاری- عاملی و شناختی) نسبت به گروه بازی‌وارسازی بی‌نشان عملکرد بهتری داشته است.

نتیجه‌گیری: یافته های پژوهش نشان داد استفاده از بازی وارسازی بر یادگیری مهارت خواندن و نوشتن و درگیری تحصیلی دانش آموزان تاثیر مثبت داشته است. از جمله پیشنهادات پژوهش می توان به مواردی مانند بهره گیری از راهبرد بازی وارسازی برای ایجاد محیط های یادگیری تعاملی، جذاب و بانشاط؛ طراحی محیط های یادگیری بازی وارسازی برای افزایش انگیزه، مشارکت، همکاری و درگیری؛ و تاثیر بازی وارسازی (تابلوی پیشگامان) برافزایش میزان کارگروهی دانش آموزان اشاره کرد.

Introduction

Academic progress of students is considered as one of the important indicators in the evaluation of education. All efforts in this system are aimed at achieving this objective. Society as a whole, and particularly the education system, shows interest and concern for the fate, successful growth, and development of children, as well as their societal position. It is expected that students make progress and excel in various aspects, including cognitive dimensions, acquiring skills and abilities, as well as in emotional and personality dimensions [1]. One of the necessities of life in the present era is to possess the skills of reading and writing to participate in society and establish constructive communication with others. Reading and writing serve as the foundation of acquiring knowledge and hold great importance, particularly in the early stages. When it comes to establishing proper communication, there is no better tool than learning one's mother tongue. Learning a language involves understanding the quality, structure, and combination of its words. If we do not have a deep understanding of how to write words correctly, their meanings become ambiguous, and we cannot effectively understand the intentions of others or convey our own intentions to others [2]. In fact, learning the skill of reading is the key to all learning types because most academic learning takes place through reading [3]. One of the issues that arises in the present era is that even individuals with a high level of literacy often misspell many Persian words, and this problem is growing. In the first grade of primary school, learning the symbols (Persian alphabet) that are necessary for reading and writing is challenging for students and requires extensive practice and repetition for them to gain mastery. Students in this grade sometimes become demotivated due to difficulties in reading words and sentences, as well as dictation, especially in the early stages of dictation. It can be tedious for students to engage in repetitive activities such as rewriting a few lines of words and sentences. As a result, they may become less involved in tasks that relate to reading and writing activities.

Many elementary school teachers are concerned about the level of reading and writing skills that their students are developing. Therefore, it is necessary to help their academic engagement with activities that strengthen their reading and writing skills. Additionally, one of the influential factors in academic progress is academic engagement. The more engaged learners are in academic issues and learning tasks, the more hopeful they can be about their academic success and reducing academic decline. Concerns regarding students' basic skills in their first year of school have heightened during and after the COVID-19 pandemic.

According to a study conducted by Salimi and Fardin [4], which focused on exploring the role of coronavirus in virtual education and the associated challenges and opportunities, approximately 8.84% of teachers noted that the COVID-19 pandemic has negatively impacted students' learning in virtual education due to the lack of lesson repetition and review opportunities. Learning in the SHAD Virtual Education Network for first-grade elementary students, who are experiencing their first year of schooling, is exhausting and tedious. Teachers frequently discuss students' lack of focus and engagement during the learning process at this level. Therefore, creating learning situations in which students can be more engaged in their assignments is an essential requirement for education in this setting. Utilizing appropriate innovative and active teaching strategies and methods, especially the implementation of technology in the field of education, can significantly contribute to improving conditions and facilitating student learning [5].

New teaching methodologies and technologies suggest creating blended learning environments for students in the 21st century [6-9]. One of the techniques that can be employed for learning and academic engagement is gamification. Gamification is a method used in systems, organizations, and activities to create experiences and motivations similar to those experienced when playing a game, while also incorporating educational goals that have an impact on the user's behavior [10]. Gamification refers to using game mechanics, visual effects, aesthetics, and game-like thinking to engage individuals, enhance motivation, improve learning, and facilitate problem-solving [11]. Gamification enriches the learning environment and supports the learner's collaboration. It has a positive impact on students engaging in beneficial collaborative behavior [12].

Some characteristics of gamification include: learner-managed learning, allowing failure and encouraging retrying without negative consequences [13], increasing joy and engagement in the classroom [14], and creating motivation in students with low literacy skills [15]. These characteristics are attributed to the game thinking element, which is considered to be the most crucial concept behind it." Zichermann and Linder [16] argue that the use of game techniques improves the ability to learn new skills. They also state that the use of game techniques enhances students' performance and motivation and helps them establish better social connections compared to traditional methods. Accordingly, gamification that uses game elements and game thinking in non-game contexts can also pursue these goals.

The goal of gamification is to integrate entertainment with education, and through positive and constructive feedback, it encourages students to engage with more interest, motivation, and stimulation in their learning [17]. Gamification allows learner to replay the gamified environment and review their mistakes, providing the freedom to fail without fear. This freedom to experience failure enables students to learn without fear and increases student engagement [14].

Gamification brings many advantages to the classroom, and the most emphasized benefit is increased student engagement in learning [18]. Therefore, gamification is considered a consistent approach to overcome challenges related to engagement and motivation [19]. Engaging individuals is one of the primary objectives of gamification. The main idea behind gamification is to transform a tedious activity into an engaging one using simple game elements, including points, badges, time, etc. Considering the importance of motivational factors in student learning, the utilization of gamification plays a significant role in the teaching and learning process [20]. Gamification combines intrinsic and extrinsic motivation to increase engagement and motivation [18]. The engagement of students in gamified learning activities can lead to improved academic performance and better learning outcomes [21]. When students are engaged in a personally gamified lesson, they have an intrinsic motivation to manage their own learning. The experiences of students participating in gamified learning courses demonstrate that they have motivation and positive attitudes towards their own learning [22].

Based on the information and research conducted both in Persian and internationally on the effects of gamification on learning and the factors influencing it, it is evident that numerous studies have been conducted in this field. In addition, domestic research has also focused on the topics of learning and motivation, examining the impact of academic engagement on students and sixth-grade students. However, overall, most studies have been conducted as single-variable studies, meaning that gamified instruction has been compared to traditional instruction in various learning variables. Furthermore, most of the research conducted has been at the elementary level and in a face-to-face setting. In this study, the researcher intends to investigate the impact of traditional instruction, gamified instruction using a coin-based point system, and gamified instruction using a coin-based point system on a leaderboard on the learning of reading and writing skills and academic engagement of first-grade elementary students in the SHAD Virtual Learning Network.

Research Questions:

- To what extent does the use of badges in gamification impact the learning of reading skills in students?
- To what extent does the use of badges in gamification impact the learning of writing skills in students?
- To what extent does the use of badges in gamification impact the academic engagement of students?

Review of the Related Literature

In this section, a summary of the most relevant research conducted in Iran on the subject of the current research is reviewed and discussed. The research objectives and their results are briefly stated. Researches are listed in order of year from the most up-to-date.

Mohammadi [23] conducted a study on the effects of competition and collaboration in gamification on fourth-grade mathematics learning and motivation. The study found that incorporating competitive, collaborative, and team-based elements had a positive impact on learning and motivation, with team-based competition being more effective. Salari [24] evaluated the effectiveness of gamification on academic engagement and learning in sixth-grade students. The study indicated that gamification, particularly through creating a competitive environment, improved learning outcomes. However, the provision of rewards did not significantly impact learning. Dehghanzadeh et al. [25] examined the impact of gamified e-learning on the academic engagement of English language learners. The study recommended incorporating gamification in higher education settings as it effectively enhanced learning outcomes and learner engagement. Mohammad-Hasani and Aghazadeh [26] investigated the influence of digital gamification, multimedia instruction, and educational games on English language learning in seventh grade. The study found significant differences in learning outcomes, with the gamification and educational game groups outperforming the multimedia group. Heydari [27] compared game-based and traditional teaching methods in mathematics learning for elementary school girls. The study showed that gamification as a teaching approach yielded better results compared to traditional methods. Ghaffari et al. [28] examined the effectiveness of educational games on the academic progress of first-grade students in the Persian language. The findings indicated that educational games were effective in enhancing academic progress, particularly in Persian language skills. Mehrabi [29] examined the impact of different methods, multimedia or Play, on learning multiplication tables in third-grade students. The study found that neither the bingo method nor the slide-making method had a significant effect on learning multiplication tables. The study revealed a significant relationship between using educational dart games and learning basic addition and subtraction concepts.

As in the above section, in this section, the background of research related to the topic of research outside of Iran has been examined. The findings and objectives of the research are briefly stated.

Clavito, et al [30] in a research named “Gamification as an Innovative Strategy to Improve Learners' Writing Skills” which conducted by pre and post-test experimental design found that there is a significant difference in the post-test and pre-test score of the learners in the gamification as an innovative strategy to improve learners' writing skills. Chan Li and Chan Chen [31] conducted a study on using a web-based collaborative reading annotation system (WCRAS) with gamification mechanisms, which resulted in improved reading performance and increased social interaction. Almutairi et al [32] found that incorporating gamification elements, such as leaderboards, in an online course led to better behavioral engagement compared to a regular course. Nand et al [33] discovered that challenge, feedback, and graphics in gamified educational content significantly improved learning outcomes and engagement. Ortiz-Rojas et al (2019) [34] reported that implementing a leaderboard in engineering education enhanced learners' performance. Hee et al [35] found that intrinsic rewards in a Chinese gamified learning system increased motivation and behavioral intention to continue learning. Zainuddin [36] conducted a study titled "Investigating Learning Performance and Motivation in a Gamified Flipped Learning Environment." The research examined two classes based on the self-determination theory - one with gamified conditions and the other with regular conditions. The study found that students in a gamified learning environment were motivated by competition and showcased characteristics such as pre-class learning motivation, readiness for competition, independence in learning, and social interaction. Additionally, the results demonstrated that a gamified class showed the characteristics of self-determination theory, such as competence, autonomy, and relatedness, and was successful in implementing them. This research revealed that gamification in a flipped learning environment positively impacted student motivation and engagement. Carlson et al [37] showed that implementing a coin counter gamification technique for classroom management had positive effects on various aspects, including classroom enjoyment, student participation, and performance. Seixas et al [18] found that gamification and rewards positively impacted student academic engagement and achievement. Han and Fox [38] surprisingly found that intrinsic motivation, social interaction, satisfaction, effort, and learning performance were better in a traditionally taught class compared to a gamified classroom. Abramovich et al [39] discovered that incorporating badges in education enhanced learner motivation and provided a personalized approach to acknowledging achievements based on individual knowledge levels.

After reviewing previous research, no studies were found that simultaneously investigated the effect of gamification on reading and writing skills and academic engagement. Based on the existing research conducted at the national and international levels, it can be concluded that most of the studies conducted in the field of gamification have been general in nature or focused on elements such as competition and collaboration. Therefore, there has been a lack of extensive research on the impact of badges, which is one of the elements of gamification. In this study, the researcher directly examines the influence of badges in gamification on the learning of reading and writing skills and academic engagement among first-grade elementary students.

Method

Participants

The research focused on practical purposes and targeted all first-grade students in Qazvin province during the 2020-2021 academic year. A primary school with two first-grade classes was selected using a multi-stage cluster sampling method. Random grouping was done through a pre-test, resulting in three groups with similar conditions: control group, gamification group with badges, and gamification group without badges, each consisting of 25 members. The study followed a pre-test and post-test experimental design with a control group. The difference between the gamification groups was that one received scores in the form of coins and badges, while the other received scores in the form of coins only. The control group received regular instruction.

Instruments

The researcher utilized a test based on Lotf-Abadi's ten-part reading skills test [40] to measure reading skills. The test also included a speed and accuracy reading assessment. The post-reading skill test was designed to be parallel to the pre-reading skill test, comprising 20 points with 5 points for reading speed and 15 points for reading accuracy. For evaluating writing skills, a test was developed by the researcher following the principles of Ragheb's foundational writing skill test design [41]. The pre-writing assessment consisted of six subtests, with the first four focusing on spelling (spelling words, writing sentences, writing image names, writing image names in blank spaces), while the fifth and sixth subtests assessed composition (writing a sentence for an image and writing two sentences for an image). The post-writing skill assessment test mirrored the pre-writing test in design. Academic engagement was measured using the Reeve Academic Engagement Questionnaire [42].

Validity and reliability of the measurement instruments

The reading and writing skills test developed by the researcher underwent face and content validity assessment. Five Elementary education experts, three teachers, and the educational supervisors (head teachers at the first-grade elementary education in the mentioned province) reviewed the test for alignment with textbook objectives, clarity, feasibility, and applicability in first-grade elementary school.

The test was revised based on their feedback, and its face and content validity were confirmed by the advisor and consultant. The reading skill assessment test showed acceptable reliability with a Cronbach's alpha of

0.701, while the writing skill assessment test demonstrated good reliability with a Cronbach's alpha of 0.807. Academic engagement was measured using the Reeve Academic Engagement Questionnaire, consisting of 17 items. The reliability of this questionnaire was found to be above 0.70 in a previous study by Ramezani and Khamesan [43].

Research implementation method/ context

The gamified intervention was designed and implemented by the teacher, who is also the researcher. Because the researcher was the teacher of the class in which the research was carried out, he was familiar with the educational needs of these students, and this helped to include the basic items that should be considered in the plan.

The study consisted of 10 sessions and included a pre-test of reading and writing skills in a SHAD environment. The writing test involved sending test images and instructions to the students in the SHAD classroom group. The reading comprehension assessment involved sending textual images to the SHAD classroom group. Each test had a duration of one hour due to internet speed and SHAD network limitations. An academic engagement questionnaire was also administered. The study had three groups: a regular educational group and two gamified groups (one with badges and one without). The gamified groups experienced a gamified environment with differences in the point system and rewards. The Forest Command 1 and 2 groups were created for the gamified groups in the SHAD platform. The game "Forest Commander" was developed using Storyline software for Android devices, and the game "See and Write" was created using Kahoot software. The "Forest Commander" consisted of 7 levels with animations or cartoons played at the beginning of each level. Each level had sub-levels with varying numbers of coins. Scores were placed on the leaderboard, creating competition among the players. In the gamified group with badges, players received flags and coins based on their scores. The leaderboard of pioneers was displayed at the end of each stage, and the top performers were chosen as the Jungle Ruler, deputies, and advisors. The gamified group without badges also had top performers chosen for these positions based on the pioneers' leaderboard. After playing the gamified learning environments, a session of the "Right or Wrong" game was conducted, where students had to determine the correctness of words or choose the correct form. Finally, all three groups participated in a simultaneous reading and writing post-test at the end of the instructional sessions. The strategies and methods employed in this research were implemented to enhance students' vocabulary to improve their reading and writing skills.

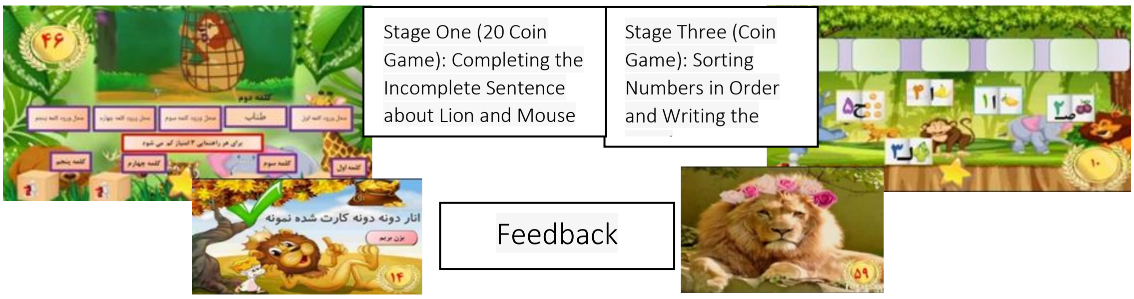

Fig. 1: The Environment of the "Forest Commander" Game

This included mastering how to construct words from symbols and effectively using consonant and vowel combinations. To achieve this, engaging activities such as matching games, puzzles, quizzes, word trains, magic numbers, token balloons, and amazing boxes can be utilized. The ultimate objective is to earn coins and different flags to become the ruler of the forest.

According to Table 1. the pre-test average scores for reading skill were 5.13 (control group), 48.13 (gamification with badges), and 54.13 (gamification without badges). For writing skill, the pre-test average scores were 16.138 (control group), 16.135 (gamification with badges), and 20.138 (gamification without badges). There was no significant difference in initial knowledge among the groups. In the post-test, the average scores for reading skill were 95.16 (control group), 58.18 (gamification with badges), and 64.17 (gamification without badges). For writing skill, the average scores were 88.254 (control group), 88.264 (gamification with badges), and 88.260 (gamification without badges). The experimental groups showed significantly increased learning compared to the control group, with the gamification with badges group performing better than the gamification without badges group.

Results and findings

Descriptive statistics

In descriptive statistics, the measures of mean and standard deviation were analyzed for each of the control groups, gamification group with badges, and gamification without badges in the pre-test and post-test of writing skill learning, reading skill learning, and academic engagement.

Table 1: Descriptive statistics of the variables of reading and writing skills learning and academic engagement

Variable	Group	Pre-test mean	Post-test mean	Pre-test SD	Post-test SD
Reading skill	Control	13.50	16.95	1/94	1.74
	Gamification with badges	13.48	18.58	1.94	1.22
	Gamification without badge	13.94	17.64	1.92	1.87
Writing skill	Control	138.16	254.88	33.09	14.95
	Gamification with badges	135.16	264.08	42.87	5.90
	Gamification without badge	138.20	260.88	34.91	8.99
Behavioral engagement	Control	16.68	17.36	2.03	2.65
	Gamification with badges	16.72	26.16	1.33	1.14
	Gamification without badge	16.56	22.48	1.29	1.75
Agentive engagement	Control	20.08	20.24	1.97	2.24
	Gamification with badges	2048	33.08	2.38	1.25
	Gamification without badge	20.28	28.04	1.67	1.54

Variable	Group	Pre-test mean	Post-test mean	Pre-test SD	Post-test SD
Cognitive engagement	Control	16.72	16.24	1.83	1.36
	Gamification with badges	16.08	26	1.52	1.44
	Gamification without badge	16.28	20.52	2.05	1.53
Emotional engagement	Control	15.64	16.16	1.38	1.17
	Gamification with badges	15.56	20.08	1.12	1.70
	Gamification without badge	15.16	20.28	1.59	2.33

According to Table 1. the pre-test mean scores for behavioral engagement were 68.16 (control group), 72.16 (gamification with badges), and 56.16 (gamification without badges). For agentic engagement, the pre-test mean scores were 08.20 (control group), 48.20 (gamification with badges), and 28.20 (gamification without badges). The pre-test mean scores for cognitive engagement were 72.16 (control group), 08.16 (gamification with badges), and 28.16 (gamification without badges). For emotional engagement, the pre-test mean scores were 64.15 (control group), 56.15 (gamification with badges), and 16.15 (gamification without badges). There were no significant differences in initial behavioral, agentic, cognitive, and emotional engagement among the students. Therefore, the students had similar levels of engagement in the Persian lesson before implementing the gamification method.

The post-test mean scores for behavioral engagement were 68.16 (control), 16.26 (gamification with badges), and 48.22 (gamification without badges). Agentic engagement scores were 80.19 (control), 08.33 (gamification with badges), and 04.28 (gamification without badges). Cognitive engagement scores were 24.16 (control), 26 (gamification with badges), and 52.20 (gamification without badges). Emotional engagement scores were 16.16 (control), 08.20 (gamification with badges), and 28.20 (gamification without badges). Experimental groups (gamification with badges and without badges) showed significant improvement in behavioral, agentic, cognitive, and emotional engagement compared to the control group. The gamification with badges group outperformed the gamification without badges group in behavioral, agentic, and cognitive engagement.

Inferential statists

To examine the inferential statistics of the impact of badges in a gamified point system on the learning of reading and writing skills and the academic engagement of first-grade elementary students, Analysis of Covariance (ANCOVA) and t-tests were employed. Prior to conducting the ANCOVA, several statistical assumptions need to be examined.

Based on the results of the Kolmogorov-Smirnov test shown in Table 2, for most research variables in the control group, the gamification with badges group, and the gamification without badges group at the pretest and posttest levels, the significance level is greater than 0.05. This suggests that the null hypothesis of data normality is confirmed at a 95% confidence level, indicating that the data follows a parametric distribution. Therefore, parametric tests can be used for further analysis of the data.

Table 2: The results of the Kolmogorov-Smirnov test in different research groups

group	Variable	Assessment Stage	Sample Size	Kolmogorov-Smirnov Statistic	Statistical Significance Level
Control	Learning Writing Skill	Pre-test	25	0.138	0.2
		Post-test	25	0.172	0.54
	Learning Reading Skill	Pre-test	25	0.110	0.2
		Post-test	25	0.155	0.125
	academic engagement	Pre-test	25	0.143	0.2
		Post-test	25	0.222	0.003
Gamification with badges	Learning Writing Skill	Pre-test	25	0.173	0.051
		Post-test	25	0.169	0.062
	Learning Reading Skill	Pre-test	25	0.1	0.2
		Post-test	25	0.173	0.052
	academic engagement	Pre-test	25	0.085	0.2
		Post-test	25	0.174	0.048
Gamification without badge	Learning Writing Skill	Pre-test	25	0.157	0.114
		Post-test	25	0.145	0.183
	Learning Reading Skill	Pre-test	25	0.148	0.162
		Post-test	25	0.166	0.074
	Academic engagement	Pre-test	25	0.128	0.2
		Post-test	25	0.101	0.2

Table 3: Results of Homogeneity of Variances Test

Variable	F	Degrees of Freedom 1	Degrees of Freedom 2	Significance Level
Learning the Writing Skill	2.99	2	72	0.056
Learning the Reading Skill	2.16	2	72	0.123
academic engagement	1.126	2	72	·0.330

Based on Table 3. the significance level in Levene's test for the variables is greater than 0.05. Therefore, the null hypothesis of variance homogeneity is confirmed as one of the assumptions of the covariance analysis.

Another necessary assumption for conducting covariance is the homogeneity of regression coefficients. Based on the observed results of the homogeneity of regression coefficients test in Table 4, it can be concluded that the significance level in all four tests (collinearity effect, Wilks' lambda, Hotelling's trace, and largest root) is less than 0.01. This suggests that the null hypothesis is rejected, indicating a significant difference at a 99% confidence level. Therefore, among the experimental and control groups, there is a significant difference in at least one of the scores related to the variables of writing, reading, and academic engagement (including behavioral engagement, agentic engagement, cognitive engagement, and emotional engagement) in the post-test.

One of the assumptions that needs to be examined for conducting covariance analysis is the homogeneity of regression slopes. Considering that the significance level in Table 5. is greater than the error level of 0.05 for all variables, the condition of homogeneity of regression slopes in the interaction between the variables is satisfied.

Table 4: Results of Homogeneity of Regression Coefficients

Tests	Values	F	Degrees of Freedom 1	Degrees of Freedom 2	Significance Level	Effect Size
Collinearity Effect	0.961	20.96	6	136	0.000	0.481
Wilks' Lambda	0.046	82.187	6	134	0.000	0.786
Hotelling's Trace	20.75	228.320	6	132	0.000	0.912
Largest Eigenvalue	20.749	470.318	3	68	0.000	0.954

Table 5: Results of Homogeneity of Regression Slopes

Variable	Source	Sum of Squares	Degrees of Freedom	Mean Squares	F	Significance Level
Learning the Reading Skill	Group*Pretest	0.948	2	0.474	0.170	0.844
Learning the Writing Skill	Group*Pretest	119.916	۲	59.958	0.521	0.596
academic engagement	Group*Pretest	94.587	۳	24.280	2.684	0.053

Research Questions

Research Question 1: To what extent does the use of badges in gamification impact students' learning of reading skills?

Based on the analysis of the data in Table 4, the F-ratio is 6.166, the effect size is 0.148, and the significance level is 0.003, indicating a significant difference in the post-test scores of the research groups at a 95% confidence level. Table 1 shows that the average learning scores of the gamified groups with badges and badge-less are higher than the control group in reading skill. Therefore, it can be concluded that gamification had a significant impact on the reading skill learning of elementary school students. The eta-squared value in the group row indicates that the effect size was 14.8%.

Based on the comparison of mean values between the control group and the gamification group with badges, the significance level (0.002) is less than 0.05. Therefore, it can be concluded that there is a significant difference between these two groups. On the other hand, in the comparison of mean values between the control group and the gamification group without badges, the significance level (0.303) is greater than 0.05.

Table 6: Results of ANCOVA on the dependent variable of reading skill learning

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	34.305	3	11/435	4.206	0.009	0.151
Mean deviation	419.419	1	419.419	154.281	0/000	0.685
Pre-test reading	0.834	1	0.834	0.307	0/581	0.004
Group	33.528	2	16.76	6.166	0/003	0.148
Error	139.016	71	2.719			
Total	23786.063	75				
Adjusted total	277.322	74				

Table 7: The results of multiple comparison of Tukey's post hoc test, control group, the gamification with badges group, and the gamification without badges group in the post-test of reading skill learning

	Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval	
						Lower Limit	Upper Limit
Post-test of reading skill learning	Control	Gamification with Badges (Coins and Flags)	-1.63	0.464	0.002	-2.74	-0.519
		Gamification without Badges (Coins)	-0.69	0.464	0.303	-1.80	0.42
	Gamification with Badges (Coins and Flags)	Control	1.63	0.464	0.002	0.5194	2.74
		Gamification without Badges (Coins)	0.94	0.464	0.113	-0.170	2.05
	Gamification without Badges	Control	0.69	0.464	0.303	-0.4206	1.80
		Gamification with Badges (Coins and Flags)	-0.94	0.464	0.113	-2.050	0.17

Therefore, it can be concluded that there is no significant difference between these two groups. Furthermore, in the comparison of mean values between the gamification group with badges and the gamification group without badges, the significance level (0.113) is greater than 0.05. Therefore, it can be concluded that there is no significant difference between these two groups.

Research Question 2: To what extent does the use of badges in gamification impact students' learning of writing skills?

Based on the analysis of the data in Table 8, a significant difference in the scores of the research groups in the post-test of writing skill is observed (F ratio= 4.888, effect size= 0.121, p-value= 0.010 < 0.05, 95% confidence level). The mean scores of writing skill learning in the gamification group with badges (combined points and badges system) and the gamification group without badges (coin-based points system) were higher compared to the control group, suggesting that gamification had a significant impact on the writing skill learning of primary school students. The squared eta value in the group row indicates that the effect size accounted for 12.1% of the variance.

The pairwise comparison of mean scores between the control group and the gamification group with badges (coin and flag system) indicates a significant difference (p-value= 0.009 < 0.05), suggesting that these two groups differ significantly. However, when comparing the mean scores between the control group and the gamification group without badges (coin system), no significant difference is found (p-value= 0.121 > 0.05), indicating that there is no significant distinction between the means of these two groups. Similarly, the pairwise comparison between the gamification group with badges and the gamification group without badges also shows no significant difference (p-value= 0.540 > 0.05) between the means of these two groups.

Table 8: Results of ANCOVA on the dependent variable of writing skill learning

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	1185.592	3	395.197	3.484	0.020	0.128
Mean deviation	323486/230	1	323486.230	2851.622	0.000	0.976
Pre-test reading	94.92	1	94.925	0.837	0.363	0.012
Group	1108.90	2	554.451	4.888	0.010	0.121
Error	8054.195	71	113.439			
Total	5077160	75				
Adjusted total	9239.787	74				

Table 9: Results of the post-hoc Tukey test comparison between the control group, the gamification group with badges, and the gamification group without badges in the post-test of writing skill learning

	Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval	
						Lower Limit	Upper Limit
Post-test of writing skill learning	Control	Gamification with Badges (Coins and Flags)	-9.20	3	0.009	-16.40	-1.99
		Gamification without Badges (Coins)	-6	3	0.121	-13.20	1.20
	Gamification with Badges (Coins and Flags)	Control	9.20	3	0.009	1.99	16.40
		Gamification without Badges (Coins)	3.20	3	0.540	-4	10.40
	Gamification without Badges	Control	6	3	0.121	-1.20	13.20
		Gamification with Badges (Coins and Flags)	—3.2	3	0.540	-10.40	4

Research Question 3: To what extent does the use of badges in gamification impact students' academic engagement?

Given that academic engagement consists of four subscales, it has been examined in detail.

To what extent does the use of badges in gamification impact students' behavioral engagement?

Based on the data analysis in Table 10. a significant difference in the level of behavioral engagement among the research groups in the post-test is observed (F= 134.462, effect size= 0.791, p-value: 0.000 < 0.05, 95% confidence level). The mean score of behavioral engagement in the gamification group with badges (coin and flag system) and the gamification group without badges (coin system) is higher compared to the control group, suggesting that gamification has had a significant impact on the behavioral engagement of primary school students. The squared eta value in the group row indicates that this effect accounts for 88.7% of the variance.

The paired comparison of mean scores between the control group and the gamification group with badges (coin and flag) reveals a significant difference in the sub-scale of behavioral engagement (p-value: < 0.05). Similarly, when comparing the mean scores between the control group and the gamification group without badges (coin), a significant difference is observed in the sub-scale of behavioral engagement (p-value: < 0.05). Furthermore, comparing the mean scores between the gamification group with badges and the gamification group without badges, a significant difference is found in the sub-scale of behavioral engagement (p-value: < 0.05).

Table 10: Results of Covariance Analysis on Behavioral Engagement Variable

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	994/604	3	331/535	91.451	0.000	0.794
Mean deviation	183.752	1	183.752	50.686	0.000	0.417
Pre-test reading	17.964	1	17.967	4.955	0.029	0.065
Group	974.937	2	487.465	134/4	0.000	0.791
Error	257.396	71	3.625			
Total	37552	75				
Adjusted total	1252	74				

Table 11: Results of Post-hoc Multiple Comparison Test (Tukey Test) on Behavioral Engagement Learning Post-test among Control Group, Gamification Group with Badges (Coin and Flag System), and Gamification Group without Badges

	Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval	
						Lower Limit	Upper Limit
Post-test Behavioral Engagement	Control	Gamification with Badges (Coins and Flags)	-8.8	0.55313	0.000	-10.12	-7.47
		Gamification without Badges (Coins)	-5.12	0.55313	0.000	-6.44	-3.79
	Gamification with Badges (Coins and Flags)	Control	8.8	0.55313	0.000	7.47	10.12
		Gamification without Badges (Coins)	3.68	0.55313	0.000	2.35	5
	Gamification without Badges	Control	5.12	0.55313	0.000	3.79	6.44
		Gamification with Badges (Coins and Flags)	-3.68	0.55313	0.000	-5	-2.35

What is the impact of using badges in gamification on students' agentive engagement?

Based on the analysis of the data in Table 12, a significant difference in post-test agentic engagement between the research groups is observed (F =349.853, effect size=0.908, p< 0.05). The mean score for the agentic engagement component in the gamification group with badges (combined coin and flag system) and the gamification group without badges (coin system) is higher compared to the control group, suggesting that gamification had a significant impact on the agentic engagement of first-grade elementary students. The squared eta value in the group row indicates that the effect size accounted for 90.8% of the variance.

Table 12: Results of ANCOVA on the dependent variable of agentive engagement

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	2098.864	3	699.621	237.60	0.000	0.909
Mean deviation	417.868	1	417.868	141.917	0.000	0.667
Pre-test reading	6.304	1	6.304	2.141	0.148	0.029
Group	2060.245	2	1030.122	349.853	0.000	0.908
Error	209.056	71	2.944			
Total	5747	75				
Adjusted total	2307.920	74				

Table 13: Results of the post-test comparison between the control group, gamification group with badges, and gamification group without badges in terms of agentive engagement

Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval	
					Lower Limit	Upper Limit
Control	Gamification with Badges (Coins and Flags)	-12.84	0.48917	0.000	-14.01	-11.64
	Gamification without Badges (Coins)	—7.8	0.48917	0.000	-8.97	-6.62
Gamification with Badges (Coins and Flags)	Control	12.84	0.48917	0.000	11.66	14.01
	Gamification without Badges (Coins)	5.04	0.48917	0.000	3.86	6.21
Gamification without Badges	Control	7.8	0.48917	0.000	6.62	8.97
	Gamification with Badges (Coins and Flags)	- -5.04	0.48917	0.000	-6.21	-3.86

The paired comparison of mean scores between the control group and the gamification group with badges (coins and flags) reveals a significant difference in the subscale of agentic engagement (p-value < 0.05). Similarly, when comparing the mean scores between the control group and the gamification group without badges (coins), a significant difference is observed in the subscale of agentic engagement (p-value < 0.05). Furthermore, a significant difference in the subscale of agentic engagement is found between the gamification group with badges (coins and flags) and the gamification group without badges (coins) (p-value < 0.05).

To what extent does the use of badges in gamification impact students' cognitive engagement?

Based on the analysis of the data in Table 14, a significant difference in cognitive engagement between the research groups in the post-test is observed (F = 348.598, effect size=0.908, p-value < 0.05, 95% confidence level). The mean score of cognitive engagement in the gamification group with badges (coin and flag system) and the gamification group without badges (coin system) is higher compared to the control group, suggesting that gamification had a significant impact on the cognitive engagement of first-grade elementary students. The squared eta value in the group row indicates that this effect accounts for 90.8% of the variance.

The comparison of mean scores between the control group and the gamification group with badges (coin and flag system) reveals a significant difference in the cognitive engagement subscale (p-value= 0.000 < 0.05). Similarly, when comparing the mean scores between the control group and the gamification group without badges (coin system), a significant difference is observed in the cognitive engagement subscale (p-value= 0.000 < 0.05). Furthermore, a significant difference in the cognitive engagement subscale is found between the gamification group with badges and the gamification group without badges (p-value < 0.05).

Table 14: Results of ANCOVA on the dependent variable of cognitive engagement

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	1222.978	3	659.407	232.4	0.000	0.908
Mean deviation	210.654	1	210.654	120.092	0.000	0.628
Pre-test reading	26.258	1	26.258	14.969	0.000	0.174
Group	1222.959	2	611.497	348.598	0.000	0.908
Error	124.542	71	1.754			
Total	34171	75				
Adjusted total	1347.520	74				

Table 15: Results of the post-test cognitive engagement comparison using the Tukey follow-up test between the control group, the gamification group with badges, and the gamification group without badges in the learning cognitive engagement

	Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval	
						Lower Limit	Upper Limit
Post-test Cognitive engagement	Control	Gamification with Badges (Coins and Flags)	-9.76	0.40934	0.000	-10.73	-8.78
		Gamification without Badges (Coins)	4.28	0.40934	0.000	-5.25	-3.30
	Gamification with Badges (Coins and Flags)	Control	9.76	0.40934	0.000	8.78	10.73
		Gamification without Badges (Coins)	5.48	0.40934	0.000	4.5	6.45
	Gamification without Badges	Control	4.28	0.40934	0.000	3.30	5.25
		Gamification with Badges (Coins and Flags)	-5.48	0.40934	0.000	-6.45	-4.50

What is the extent of the impact of using badges in gamification on students' emotional engagement?

Based on the analysis of data in Table 16. it can be concluded that there was a significant difference in emotional engagement between the research groups in the post-test (F= 43.546, effect size= 0.551, p-value= 0.000 < 0.05, 95% confidence level). The mean score of emotional engagement in the gamification group with badges (coin and flag system) and the gamification group without badges (coin system) is higher compared to the control group, indicating that gamification has a significant impact on the emotional engagement of elementary school students. The squared eta value in the group row suggests that this effect accounts for 55.1% of the variance.

The pairwise comparison of means between the Control Group and the Gamification Group with Badges (Coin and Flag System) indicates a significant difference in the sub-scale of emotional engagement (p-value= 0.000 < 0.05). Similarly, the pairwise comparison of means between the Control Group and the Gamification Group without Badges (Coin) also shows a significant difference in the sub-scale of emotional engagement (p-value= 0.000 < 0.05). However, when comparing the means between the Gamification Group with Badges and the Gamification Group without Badges, no significant difference was found in the sub-scale of emotional engagement (p-value= 0.919 > 0.05).

Table 16: Results of the analysis of covariance on the dependent variable of emotional engagement.

Source	Sum of squares	Degrees of freedom	Mean squares	F ratio	Significance level	Effect size
Adjusted model	287	3	92.787	29.186	0.000	0.552
Mean deviation	128.192	1	128.192	40.323	0.000	0.362
Pre-test reading	8.52	1	8.52	2.68	0.106	0.036
Group	276.877	2	138.438	43.546	0.000	0.551
Error	225.720	71	3.179			
Total	27125	75				
Adjusted total	504.08	74				

Table 17: Results of the post-test emotional engagement multiple comparison using the Tukey follow-up test between the control group, gamification group with badges (coin and flag system), and gamification group without badges in the learning emotional engagement

	Group A	Group B	Mean Difference (A-B)	Standard Deviation Error	Significance Level	Confidence Interval Lower Limit	Confidence Interval Upper Limit
Post-test Emotional engagement	Control	Gamification with Badges (Coins and Flags)	-3.92	0.51016	0.000	-5.14	-2.69
		Gamification without Badges (Coins)	-4.12	0.51016	0.000	-5.34	-2.89
	Gamification with Badges (Coins and Flags)	Control	3.92	0.51016	0.000	2.69	5.14
		Gamification without Badges (Coins)	-0.2	0.51016	0.919	-1.42	1.02
	Gamification without Badges	Control	4.12	0.51016	0.000	2.89	5.34
		Gamification with Badges (Coins and Flags)	0.2	0.51016	0.919	-1.02	1.42

Discussion

Gamification leads to improved learning activities. A gamified learning environment plays an effective role in teaching and learning processes. Salari's research [24] titled "Investigating the Effectiveness of Gamified Learning on Academic Engagement and Learning shows that gamified learning, through creating a sense of competition, can enhance students' learning outcomes. Providing rewards does not have a significant impact on learning, but gamified learning, through creating a sense of competition and rewards, increases academic engagement. In another research by Ghaffari et al [28], the effectiveness of educational games on the academic progress of first-grade students in Persian Language was studied. The findings showed that educational games can enhance the academic progress of first-grade students in the Persian language, specifically in reading and writing skills, as well as word and image comprehension. Furthermore, the impact of gamification on word recognition and vocabulary recall was found to be significant, leading to improved word comprehension and content recall. It was found that gamification can positively affect the academic progress of first-grade students when learning the Persian language. This means that when students use gamification, their reading and writing skills improve, they retain the content better, and they have an enhanced understanding of words and vocabulary. In line with the researches, in the current study, based on the higher average scores in the reading and writing skills of students in gamified groups with and without badges compared to the control group and the follow-up test, it can be concluded that gamification has been effective in enhancing students' reading and writing skills. The findings of this study are consistent with the results of the studies by Zainuddin [36], Carlson et al [37], Chen et al [31], Nand et al [33], Mohammadi [23], Salari [24], Agazadeh and Mohammadhasani [26], Heydary [27]. These results are particularly in line with the studies by Ortiz-Rojas and colleagues [34] and Ghaffari et al [28]. The mentioned studies have obtained significant results regarding the impact of gamification on learning. Additionally, the results of this study differ from the results of the studies by Mehrabi [29], Chen [31], He et al [35], Hans Hanus and Fox [38].

Gamification-based learning has positive effects on student participation and engagement. Gamified learning environments attract learners' attention through factors such as focus, communication, confidence, and satisfaction, and gamification elements are designed based on learners' prior knowledge and learning goals. Challenges and skills in these environments are tailored to the abilities of the students. Students feel a sense of satisfaction in these environments and apply what they have learned in other situations. Research shows that gamified learning environments based on the ARCS theory (Attention, Relevance, Confidence, Satisfaction) increase students' interest and engagement in various activities. Various studies demonstrate that game-based e-learning can significantly improve student engagement. Additionally, the use of gamification in education can enhance the level of learning and engagement among students. Features such as challenges, feedback, and graphics play a crucial role in improving the level of learning. Research indicates that incorporating gamification leads to increased student participation and engagement in learning activities. Moreover, the use of educational badges can enhance learner motivation and positively impact their intrinsic motivation. Badge acquisition patterns may vary based on learners' prior knowledge. Overall, the use of gamification in education can facilitate improved student participation and engagement. Considering the increase in the average scores of the sub-scales of academic engagement (behavioral, emotional, cognitive, and agentic) in gamified groups with and without badges compared to the control group, pre-test and post-test comparison and the data obtained from the analysis of covariance, it can be concluded that gamification has been effective in promoting students' academic engagement. The findings of this study are consistent with the research by Nand et al [33], Seixas et al [18], Dehghanzadeh et al [25], and Salari [24]. The mentioned studies have obtained significant results regarding the impact of gamification on increasing student engagement and participation. Based on the results, it can be concluded that there is a significant difference in the mean scores of the sub-scales of academic engagement (behavioral, emotional, and cognitive) between the gamified group with and without badges. These results are particularly in line with the research by Almotairi et al [32], He et al [35], Carlson et al [37], and Abramovich et al [39], which have examined the impact of point systems, leaderboards, badges, and rewards.

Conclusions

This study found that gamification positively impacts learning and academic engagement. Two gamified groups showed improved performance in reading, writing, and engagement. Gamification elements like challenges, competition, feedback, and rewards increased student engagement. Students were highly engaged in the Forest Commander game, playing multiple times and seeking uninterrupted access. The game's challenges and missions aligned with learning objectives and increased in complexity as students progressed. Written and audio feedback, along with rewards, motivated learners. The badge gamified group had a combined badge and coin system, while the badgeless group had only coins. The badge gamified group showed higher academic engagement in three subscales. Both gamified groups had higher academic engagement than the control group.

Gamified environments enhance academic success, creativity, critical thinking, professional skills, and social skills. These environments align with the ARCS motivation theory, capturing attention, relevance, confidence, and satisfaction. They provide tailored challenges and skills, leading to satisfaction and effective application of knowledge. Interactive and multiplayer gamified environments facilitate interaction and collaboration. Gamification offers unique learning experiences and allows for trial and error without fear of failure. It can also be beneficial in therapeutic domains for addressing learning disorders, stress, and attention deficits.

Based on the importance of gamification in education and the results of the current research, some practical suggestions and also some recommendations for future research can be included: Design educational programs using gamification principles and badges to encourage students in the learning process. Select badges based on educational goals to provide a learning environment creatively and attractively. The gamification scoring system should include an effective feedback process for students. Use Badges as a feedback mechanism can help students improve their reading, writing, and academic engagement skills and stay on track for their progress. Raise awareness of the new gamification method in education for teachers and parents through in-service training courses. Conducting similar research with a larger sample size and longitudinal research on the subject of the current research. Conduct similar research on the current research topic in other educational levels.

It should be noted that there were some limitations in the research conducted. For instance, some students were unable to install the "Jungle Commander" game on their mobile phones due to having lower versions of the Android operating system. As a result, they had to use shared devices. Additionally, the study focused solely on 1st-grade female students. It's important to note that boys tend to be more comfortable in game environments due to their frequent use of electronic devices; therefore, the results of the study may differ for them.

Authors' Contribution

The authors contributed equally to the writing of this article. Zohre Morovati performed the initial drafting of the manuscript, Nasrin Mohammadhasani was responsible for Project administration, Writing, Review and Editing, and Yousef Mahdavinasab conducted the manuscript revision and methodology.

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Conflicts of Interest

The authors have no conflicts of interest

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ORIGINAL RESEARCH PAPER

On the Regulatory Engagement, Internet Self-efficacy, Course Satisfaction, and Reading Comprehension in Online English Classes

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ABSTRACT

Background and Objectives: Online learning involves a complex array of factors that collectively shape the educational experience. One key element is learning engagement, which enhances academic performance, knowledge retention, and overall course satisfaction. Another important aspect is self-regulation; these skills are essential for success in online courses due to the lack of external structure and supervision. Additionally, internet self-efficacy and course satisfaction significantly impact the effectiveness of online education. Considering and addressing these elements can lead to a deeper understanding of online learning.

Materials and Methods: This study involved 315 students, aged 18-22, enrolled in a general language course at a university in Tehran, Iran. Of these, 282 completed the online questionnaires. The study utilized four questionnaires and an English test, including the Online Self-Regulation Questionnaire (30 items), the Online Student Engagement Scale (19 items), the Online Learning Self-Efficacy Scale (22 items), the Course Satisfaction Questionnaire (21 items), and the reading section of the TOEFL (40 items). These were administered through the university's virtual education platform. Persian versions of the questionnaires were used to ensure students' comprehension. Since these questionnaires had not been previously published or available in Iranian research journals, the researcher translated them with the assistance of two professors proficient in both languages. Back translations ensured accuracy. This descriptive correlational study included statistical analyses such as reliability, correlation, and regression, alongside a thorough construct validity assessment. Additionally, mediation analysis was conducted to examine the complex effects of course satisfaction and internet self-efficacy on the relationship between regulatory engagement and reading comprehension.

Findings: The Cronbach's alpha values for self-regulation, engagement, self-efficacy, course satisfaction, and the reading test were .94, .90, .90, .93, and .86, respectively, indicating strong reliability and internal consistency of the instruments. The RMSEA values for engagement, self-regulation, satisfaction, self-efficacy, and reading were 0.08, 0.07, 0.08, 0.07, and 0.01, respectively, demonstrating satisfactory results. Notably, a coefficient of 0.84 was observed between self-regulation and engagement, and 0.7 between self-efficacy and satisfaction. A bivariate correlation of 0.7 or higher can present challenges in testing and interpreting regression coefficients. To better understand these relationships, the researcher created composite variables named 'regulatory engagement' and 'satisficacy' (course satisfaction and internet self-efficacy). The β index for satisficacy was .47 ($p = .00$), indicating it as a significant predictor of the learning outcome, while the β index for regulatory engagement was .06 ($p = .26$), showing a weaker prediction. This finding suggested that regulatory engagement indirectly influenced learning outcomes via satisficacy, with satisficacy ($\eta2=.81$) being a significant predictor and regulatory engagement ($\eta2=.47$) having an indirect effect through satisficacy. This underscores the critical role of regulatory engagement in enhancing satisficacy and its impact on learning.

Conclusions: The results of this study highlight the importance of promoting regulatory engagement to improve satisfaction and self-efficacy, thereby enhancing reading comprehension. However, this study has its limitations. The data collected from the current sample may not be fully applicable to other contexts. Moreover, the composite variables introduced in this study may add complexity and require further validation in different settings. Future research should investigate the intricate relationships between regulatory engagement, satisficacy, and reading comprehension, considering additional variables and assessing the generalizability of these findings across various populations.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
67	2	6

جایگاه مشارکت فعال، خود تنظیمی یادگیری، خودکارآمدی اینترنتی و رضایت تحصیلی در مهارت خواندن در کلاس‌های بر خط انگلیسی

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۰۹۳۵-۲۳۳۷۳۴۴

چکیده

پیشینه و اهداف: یادگیری آنلاین شامل مجموعه پیچیده ای از عوامل است که تجربه آموزشی را شکل می دهند. یکی از عناصرمهم مشارکت فعال در یادگیری است که پیشرفت تحصیلی، حفظ دانش و رضایت از آموزش بر خط را افزایش می دهد. جنبه مهم دیگر در یادگیری خود تنظیمی است. این مهارت ها برای موفقیت در دوره های آموزشی بر خط به دلیل نبود تعامل حضوری بین دانشجو و استاد ساختار بسیار ضروری هستند. علاوه بر این، خودکارآمدی اینترنتی و رضایت از دوره به میزان قابل توجهی بر اثربخشی آموزش بر خط تأثیر می‌گذارد. در نظر گرفتن و پرداختن به این عوامل می تواند به درک عمیق تر از آموزش بر خط منجر شود.

روش‌ها: در این پژوهش ۳۱۵ دانشجو ۱۸ تا ۲۲ شرکت کردند. آن ها در یک دوره زبان عمومی در یکی از دانشگاه‌های تهران ثبت نام کرده بودند. از این تعداد، ۲۸۲ نفر پرسشنامه های مربوط را در بستر آموزش مجازی تکمیل کردند. در این مطالعه از چهار پرسشنامه و یک آزمون خواندن زبان انگلیسی، شامل پرسشنامه خودتنظیمی یادگیری بر خط (۳۰ گویه)، مقیاس مشارکت فعال در یادگیری بر خط (۱۹ سؤال)، مقیاس خودکارآمدی یادگیری بر خط (۲۲ سؤال)، پرسشنامه رضایت از دوره اموزشی (۲۱ سؤال) و بخش ریدینگ تافل (۴۰ مورد) استفاده شد. پرسشنامه ها و آزمون تافل از طریق بستر آموزش مجازی دانشگاه اجرا می شد. برای اطمینان از درک دانشجویان از نسخه فارسی پرسشنامه استفاده شد. از آنجایی که این پرسشنامه ها قبلاً در مجلات پژوهشی ایران منتشر نشده بود محقق با کمک دو استاد مسلط به زبان انگلیسی و فارسی آنها را ترجمه کرد. ترجمه های مذکور به روش ترجمه معکوس بررسی و نسخه نهایی آماده شد. این مطالعه از نوع توصیفی همبستگی است. تجزیه و تحلیل های آماری مانند پایایی، همبستگی و رگرسیون همراه با ارزیابی اعتبار سازه انجام گرفت. علاوه بر این، تجزیه و تحلیل میانجی برای بررسی اثرات پیچیده رضایت از درس و خودکارآمدی اینترنتی بر رابطه بین مشارکت نظارتی و درک مطلب انجام شد.

یافته‌ها: مقادیر آلفای کرونباخ برای خودتنظیمی، مشارکت فعال، خودکارآمدی، رضایت از درس و آزمون خواندن به ترتیب ۰/۹۴، ۰/۹۰، ۰/۹۰، ۰/۹۳ و ۰/۸۶ بود که نشان دهنده پایایی قوی و انسجام درونی است. مقادیر RMSEA برای سازه های مشارکت فعال، خودتنظیمی یادگیری، رضایت از درس، خودکارآمدی و خواندن به ترتیب ۰/۰۸، ۰/۰۷، ۰/۰۸، ۰/۰۷ و ۰/۰۱ بود که نتایج رضایت بخشی را نشان می‌دهد. قابل ذکر است که بین خودتنظیمی و مشارکت فعال ضریب ۰/۸۴ و بین خودکارآمدی و رضایت از درس ۰/۷ مشاهده شد. اگر همبستگی بین دو متغیره ۰.۷ یا بالاتر می تواند چالش هایی را در سنجش این عوامل وتفسیر ضرایب رگرسیون ایجاد کند. برای درک بهتر این روابط، محقق متغیرهای ترکیبی به نام‌های «مشارکت خود تنظیم» و «رضایت از کارآمدی» (رضایت از دوره و خودکارآمدی) را ارائه کرد. شاخص β برای رضایت از کارامدی ۰/۴۷ (p = 00/0) بود که نشان می دهد این عامل یک پیش‌بینی‌کننده مهم برای تبیین نتیجه یادگیری است، در حالی که شاخص β برای مشارکت خود تنظیم ۰/۰۶ بود (p = 26/0)، که پیش‌بینی ضعیف‌تری را نشان می‌دهد. این یافته نشان می‌دهد که مشارکت خود تنظیم به‌طور غیرمستقیم ، یعنی با واسطه رضایت از کارآمدی بر یادگیری تأثیر می‌گذارد. رضایت از کارآمدی»(81/0=η2) یک پیش‌بینی‌کننده بسار مهم و مشارکت خود تنظیم

(η2=.47) اثر غیرمستقیم دارد. این امر بر نقش مشارکت خود تنظیم در افزایش رضایت و تأثیر آن بر یادگیری صحه می گذارد.

نتیجه‌گیری: نتایج این مطالعه بر اهمیت افزایش مشارکت خود تنظیم برای بهبود رضایت و خودکارآمدی و در نتیجه افزایش درک مطلب تأکید می‌کند. با این حال، این مطالعه محدودیت های خود را دارد. داده‌های جمع‌آوری‌شده از نمونه فعلی ممکن است به طور کامل برای دانشجویان در بافت های دیگر قابل اجرا نباشد. علاوه بر این، متغیرهای ترکیبی معرفی‌شده در این مطالعه ممکن است باعث پیچیدگی بیشتر متغیرهای این پژوهش شوند و نیاز به اعتبارسنجی بیشتر در ساختارهای مختلف آموزشی داشته باشند. تحقیقات آینده باید روابط پیچیده بین مشارکت خود تنظیم، رضایت از خودکارآمدی و نقش آن ها در درک مطلب انگلیسی را بررسی کند و تعمیم پذیری این یافته ها را در جوامع آماری مختلف ارزیابی کند.

Introduction

Drawing upon technology-based learning, online instruction can facilitate the teaching and learning processes and can expand educational opportunities, thereby acting as an agent of development of life-long learning, benefiting individuals, communities, and societies across the world. Online instruction helps learners to access educational resources and materials at their convenient time and place. According to Marshall [1], technology-based learning tools can enhance the learning experience by providing interactive and engaging content.

Online platforms can incorporate multimedia features, such as videos, animations, and simulations, which can help illustrate complex concepts and engage learners in a more interactive manner. Moreover, online platforms frequently provide adaptive learning systems that tailor the learning experience to individual needs and preferences [2]. Additionally, online instruction promotes collaborative learning. Technology allows learners to connect and collaborate with peers and instructors from different locations. The online video conferencing tools, discussion forums, etc., allow learners to exchange opinions and collaborate on tasks and projects [3].

Online instruction is a multifaceted process encompassing learning engagement, self-regulation, internet self-efficacy, course satisfaction, and a host of other variables. Learning engagement contributes to better academic outcomes, knowledge retention, and overall satisfaction with the online course [4-7]. Self-regulation is another significant issue in online instruction [8-11]. Developing self-regulation skills seems vital for succeeding in online courses, as there is usually little external structure or supervision. Internet self-efficacy and course satisfaction play critical roles in the success of online instruction [6, 11-12].

This study investigates these factors among Iranian students, filling a gap in the literature by examining the interplay of self-regulation, internet self-efficacy, and course satisfaction in shaping online learning outcomes. By studying these relationships, the research aims to offer valuable insights that enhance our understanding of online learning and support the development of more effective instructional strategies.

Review of the Related Literature

Self-regulated learning (SRL) entails students actively and purposefully engaging in their own learning process. It involves setting goals, monitoring progress, adapting strategies, and taking responsibility for one's own learning [13-14]. It is often assumed that highly self-regulated students may be more driven, engaged, and determined to manage the challenges of online learning, such as self-discipline, time management, and organization skills. Conversely, students with lower self-regulated learning (SRL) abilities may have a hard time with online tasks. This struggle can lead to frustration, confusion, and dissatisfaction with online learning. While this perspective aligns with prior findings, it is important to acknowledge that even students with strong SRL skills may experience similar challenges in poorly designed or overly demanding online courses.

However, while previous studies have confirmed a connection between SRL and satisfaction with online learning [15-20], it is essential to critically assess the extent and nature of this relationship rather than assume its universality. Some research suggests that self-regulated learners tend to demonstrate a higher inclination towards assuming responsibility for their learning, seeking assistance when necessary, and actively participating in online courses [21]. This active engagement is believed to facilitate deeper comprehension and a more fulfilling learning experience. However, the degree to which SRL enhances online learning satisfaction may depend on contextual factors such as course design, instructor support, and technological affordances.

A closer examination of the mechanisms through which SRL influences satisfaction reveals several contributing factors:

-Motivation and engagement go hand in hand: Students exhibiting higher levels of self-regulated learning (SRL) are often more actively involved in their educational pursuits [22-23]. They establish meaningful objectives and consistently strive to achieve them. Such determination and engagement play a pivotal role in fostering their overall contentment with the online learning journey.

-Adaptability and flexibility: Online learning often requires students to navigate through various tools, resources, and assignments independently. Students with strong SRL skills can adapt to different situations, manage their time efficiently, and regulate their efforts as demanded in the online environment [24]. This adaptability enhances their satisfaction with online learning, as they feel confident and capable of handling the challenges that arise.

-Self-assessment and monitoring: SRL entails consistently tracking one's progress and recognizing areas that need improvement. Students who proactively evaluate their own performance in online learning are more inclined to promptly address any knowledge or skill gaps. This self-awareness and evaluation contribute to their satisfaction, as they can see their growth and development over time [25].

-Goal attainment and success: Students exhibiting strong SRL tendencies may set practical and specific objectives for themselves. They establish strategies to accomplish these goals, whether they pertain to finishing assignments, gaining knowledge, or mastering new skills. When students achieve their goals through their SRL efforts, they experience a sense of accomplishment and satisfaction [26].

-Autonomy and ownership: Online learning offers students more autonomy and ownership over their learning journey. Students with strong SRL skills can take full advantage of this independence by actively managing their learning process. They decide on when, where, and how to learn, which enhances a sense of satisfaction. According to Nicol [27], students demonstrated increased self-reliance in online learning, which aligns with the core essence of self-regulated learning (SRL). Meanwhile, Joo et al. [28] discovered an indirect correlation between these factors. Nonetheless, Kuo et al. [29] found no significant relationship, suggesting that autonomy alone does not necessarily lead to satisfaction.

To sum up, while SRL plays a crucial role in shaping students' experiences in online learning, its impact on satisfaction is not straightforward. The relationship between SRL and satisfaction is influenced by multiple factors, including course structure, technological usability, and the availability of support systems. Thus, rather than viewing SRL as a universally beneficial trait, research should explore how its effects vary across different learning contexts and student populations.

Studies investigating online instruction have demonstrated that highly efficacious students excel in completing academic tasks and exhibit robust self-regulatory abilities. Mastery of these skills correlates with enhanced academic achievements. For instance, students with high self-efficacy are usually able to set effective goals, manage their time effectively, and check their own progress, which improves their ability to successfully complete academic tasks. Conversely, individuals with low self-efficacy typically exhibit inadequate self-regulatory skills, resulting in unfavorable academic outcomes due to difficulties in managing learning habits [30- 33].

While these findings are widely supported, the focus on self-efficacy as a determinant of self-regulation requires further exploration, particularly in online learning contexts. The assumption that self-efficacy directly translates into improved self-regulation may overlook other complex factors that influence learning outcomes. For instance, studies tend to assume a linear relationship between self-efficacy and academic success, yet this relationship may be moderated by external factors such as social support, motivation, and technological competence, all of which can vary significantly in online environments.

A person's self-efficacy, which represents their belief in their own capabilities to accomplish tasks, plays a crucial role in effectively regulating learning behaviors, including goal setting, time management, and progress monitoring [34]. On the other hand, students with low self-efficacy may experience reduced confidence in their potential for success, ultimately influencing their motivation, engagement, and persistence in online learning [35].

Bandura suggests that several factors, such as mastery experiences, vicarious experiences, verbal persuasion and social influence, and physiological and affective states, can influence one’s self-efficacy [34]. These sources play a central role in evaluating the learners' abilities and ultimately influence their decision as to whether to engage in a particular task or not. Mastery experiences refer to successful past experiences in which the individual has accomplished a similar task or goal. When someone has previously done well in an activity, most probably they do well in future similar cases.

Vicarious experiences involve observing others successfully completing a task. By witnessing others' achievements, individuals can gain confidence in their own capabilities to complete similar tasks. This can be particularly persuasive when individuals identify with those they observe, such as role models or peers. Verbal persuasion and social influence refer to the encouragement or discouragement individuals receive from others regarding their capabilities. Positive feedback and support can enhance self-efficacy, while negative feedback and criticism can lower it. The opinion of influential others, such as teachers, parents, or friends, can greatly affect one's self-efficacy beliefs [36]. Physiological and affective states can also influence self-efficacy. When individuals feel an increased heart rate or anxiety, they may interpret these physical reactions as signs of ineffectiveness and low self-efficacy. Conversely, positive emotions and a calm state can enhance self-efficacy views [37].

Overall, these four types of self-efficacy provide people with an assessment of their abilities that leads to either motivation and persistence on a task or avoidance and withdrawal. By understanding issues influencing self-efficacy, people may become more confident and do the tasks with more assurance. Furthermore, the influence of verbal persuasion in online settings is often mediated by the quality and frequency of feedback provided by instructors, peers, or automated systems. While positive reinforcement can enhance self-efficacy, inconsistent or non-personalized feedback may fail to motivate students or even diminish their sense of competence. Similarly, the physiological and affective states described by Bandura [34] may be more challenging to interpret in an online environment where students are working in isolation, possibly leading to misinterpretations of anxiety or stress as signs of incompetence rather than common reactions to online learning pressures.

Repeated failures or negative experiences can weaken one's self-efficacy beliefs. The sources of failure are not always straightforward in an online learning context. For example, mastery experiences are often less frequent or harder to gauge without immediate feedback or face-to-face interaction, making it more challenging for students to build self-efficacy in virtual environments. Moreover, while vicarious experiences can still play a role through online peer interactions or video tutorials, the lack of direct, personal feedback may weaken the impact of this source.

According to Zimmerman and Schunk [14], self-regulation is considered crucial for the cultivation of self-efficacy, yet it is not always clear how self-regulation strategies (e.g., self-monitoring, goal-setting) are cultivated in online learners. When learners with high self-regulation tendencies involve themselves in some activities like self-monitoring, they show proof of their progress. This feeling enhances their self-confidence. Alternatively, Bandura [33] maintains that self-efficacy plays a key role in the development of self-regulation. In general, as clarified earlier, the four bases of self-efficacy shape one's certainty in their capacity to arrange and carry out the necessary actions to accomplish a task.

Numerous research papers have revealed the correlation between self-efficacy and self-regulatory skills within academic environments. Pintrich and De Groot's [32] research illuminated the advantageous bearing of strong self-efficacy and self-regulation on students' accomplishments in traditional classes. These scholars characterized self-regulated learners as students who employed metacognitive tactics such as planning, monitoring, and adjusting their cognitive processes. The findings revealed that higher levels of self-efficacy and a genuine appreciation for the assigned task (viewing it as interesting and important) were associated with increased utilization of cognitive strategies, heightened metacognitive activity, improved student self-regulation, and elevated levels of achievement across various projects, including essays, quizzes, seatwork assignments, lab problems and teacher-made tests.

Joo et al. [31] attested that some aspects of self-regulation and self-efficacy go together to shape educational accomplishment in Web-based courses. They attained a positive connection between self-regulated learning, internet self-efficacy, and academic attainment.

In summary, while extensive research highlights the positive impact of self-efficacy and self-regulation on academic performance, existing studies do not fully capture the complexities of these relationships in online learning environments. Future research should explore how these factors interact in digital settings, considering the limitations of traditional models and the specific challenges online learners face. Moreover, greater emphasis should be placed on individual differences and external influences, such as instructor presence, peer interaction, and access to technology, as these elements can play a crucial role in shaping self-efficacy and self-regulation in virtual learning spaces.

Student satisfaction is an important factor in academic success, shaping motivation, engagement, and overall performance. It reflects students' perceptions and evaluations of their educational experiences. It is influenced by various factors, such as instructional quality, curriculum effectiveness, levels of participation and interaction, and the outcomes achieved [38].

According to Gray and DiLoreto [38] satisfaction is shaped by many factors, including the teaching methods, the level of feedback and support provided by peers and instructors, the availability of means and technology, and the overall learning environment. However, these factors are often examined separately, overlooking the ways in which they influence one another. For example, while access to technology is crucial, it alone does not ensure a fulfilling learning experience unless supported by effective teaching methods and active student engagement.

Online learning satisfaction involves the assessment of learners' opinions and emotional experiences towards the excellence of online learning services delivered by providers. It represents a holistic psychological response emerging from a balanced evaluation of the actual perceived effectiveness of online learning content and environment, put together with the learners' initial expectations [39].

Online learning satisfaction has gathered significant research attention, particularly with the advent of COVID-19 [40- 42]. Notably, there has been a fervent discussion surrounding the factors influencing online learning satisfaction [43]. Several factors have emerged as significant contributors to online learning satisfaction. These include the role of online instructors [44], the collaboration between teachers and learners in the online environment [17], the observed effectiveness of online learning courses [45], the quality of online learning subject matter [46], the efficacy of platform machinery [47], the learners' motivation and efficacy within the online learning setting [48] and the presence of robust evaluation systems [47]. While these studies provide valuable insights, they often rely on self-reported measures of satisfaction, which may be influenced by students' biases, previous experiences, or external pressures. Moreover, satisfaction levels may be contingent on students’ prior exposure to online learning, raising questions about the generalizability of findings across diverse learner populations.

Online learners' satisfaction plays a key role in boosting their perseverance. Several studies prove that learners who are content with their online learning quality are more likely to stay motivated, complete their courses, and achieve success. For instance, Ali and Ahmed [49] discovered a positive correlation between satisfaction and student retention in online courses. Likewise, Paepe et al. [50] noted that high levels of satisfaction were linked to lower dropout rates among online learners. Satisfaction is not the only factor influencing retention; external elements such as financial constraints, workload, and institutional support also play significant roles.

Student satisfaction emerges as a dependable indicator of online learning excellence. Eom and Ashill [51] found a positive correlation between satisfaction, perceived learning outcomes, and overall course quality. Kauffman [52] viewed satisfaction as a noteworthy predictor of student engagement and academic success in online courses. Furthermore, Yukselturk and Yildirim [53] highlighted satisfaction's influential role as a predictor of student success in online learning settings.

Generally, these discoveries put emphasis on the importance of satisfaction in encouraging student engagement, motivation, and success in online learning settings. Emphasizing the creation of excellent learning environments that align with learners' needs and expectations, educators can foster satisfaction, providing vital support for their students' perseverance and accomplishments.

Gray and DiLoreto [38] believe that student satisfaction and accomplishment play a key role in assessing the success of online instruction. When the learners feel pleased with their online classes, it enhances their engagement and motivation, ultimately resulting in improved academic performance. Richardson and Swan [54] also discovered a strong link between satisfaction with online learning and academic achievement, thus reinforcing the support for this claim.

Student achievement and satisfaction hold great importance as primary learning outcomes, serving as pivotal indicators of educational quality [55]. The level of satisfaction students experience with a course can significantly influence their decisions regarding continued enrollment or withdrawal [56]. This emphasizes the critical role of satisfaction in shaping students' educational career. Furthermore, satisfaction is not only associated with retention but is also recognized as a crucial aspect of achieving successful learning outcomes [57].

A further dimension of satisfaction is its connection to self-efficacy. Pajares and Miller [58] have established a link between student satisfaction and self-efficacy. They have emphasized that a strong sense of efficacy contributes to overall comfort. For instance, self-efficacy convictions have the potential to impact the levels of stress and anxiety experienced by individuals during their engagement in activities [59]. This principle applies to students as well, implying that their self-efficacy may influence their satisfaction with a course. However, this perspective raises a question of directionality—does self-efficacy enhance satisfaction, or does satisfaction reinforce self-efficacy? Some scholars, such as Marks et al. [59], contend that achieving concrete learning outcomes boosts satisfaction, implying that performance may shape students' perceptions rather than vice versa. The authors additionally observed that students' achievement effects are reliable indicators of student gratification, suggesting that educators can use student success as a measure of the effectiveness of their online practice.

Overall, these researches believe that academic satisfaction and achievement are closely related and may serve as dependable signs of the effectiveness of online training. By specializing in developing high-quality learning that promotes student engagement, motivation, and achievement, educators can support the satisfaction and achievement of their students in online environments.

Satisfaction with courses may boost students' self-belief in their potential to be successful. This accelerated self-belief, called self-efficacy, plays an important role in their instructional journey. Furthermore, course satisfaction promotes self-regulation amongst college students. When students are content with their instructors, they may be more likely to undertake behaviors that enhance their learning, which include regular attendance, timely finishing assignments, and looking for help when needed. As a result, their academic performance tends to improve due to the fact that they become good at staying focused and effectively handling their own learning.

Previous studies have proved the significance of self-efficacy and self-regulation in traditional classes. These studies consistently demonstrate that students with higher self-efficacy and stronger self-regulatory skills tend to achieve better academic outcomes. However, their impact on student attainment in online learning settings remains uncertain. Online instruction introduces unique challenges and opportunities compared to traditional education. Students have to navigate virtual platforms, correctly control their time, and maintain motivation and engagement in the absence of direct interactions with instructors and friends. Understanding how self-efficacy and self-regulation contribute to student satisfaction and fulfillment in online contexts seems helpful. This knowledge can guide the development of interventions and techniques that assist students in online environments, ultimately improving their achievements and outcomes. Although previous research recognizes these challenges, there is little empirical evidence on how self-efficacy and self-regulation interact with factors like course satisfaction and engagement to impact academic success in online learning.

This study addresses this gap by examining the interrelationships among course satisfaction, self-efficacy, self-regulation, and academic attainment amongst students in an online learning environment. Previous studies have examined these variables in isolation; however, few studies have investigated how they interact with each other and collectively impact student success. Understanding whether satisfaction is a consequence of learning outcomes, as suggested by Marks et al. [59], or whether it functions as a key predictor of academic success remains an open question. Additionally, it remains unclear which factor—engagement, self-efficacy, self-regulation, or satisfaction—has the strongest impact on reading comprehension in online learning. To address these gaps, this study specifically seeks to answer the following research questions:

- Does learning outcome promote satisfaction as claimed by Marks et al. [59]?
- Which of the following factors - engagement, self-efficacy, self-regulation, or satisfaction is a stronger predictor of reading comprehension?

Participants

This study involved 315 undergraduate students enrolled in a compulsory general language course at a university in Tehran, Iran. The participants, aged 18 to 22, were selected as they represent a population commonly engaged in online learning environments, providing a suitable context for exploring factors influencing online learning outcomes. Tehran was chosen due to its diverse student population and the widespread adoption of online education, particularly in the post-COVID-19 era, which aligns with the study's focus on internet self-efficacy, self-regulation, and satisfaction.

Of the initial pool of participants, 282 students completed the questionnaires. However, 18 responses were excluded due to incomplete or contradictory answers that could introduce bias into the analysis. These exclusions were necessary to ensure the reliability and validity of the results. The final analysis was conducted on 264 complete and accurate responses. While these exclusions reduced the sample size, they did not compromise the representativeness of the data, as the excluded responses accounted for only a small proportion of the total sample.

Instruments

The purpose of this study was to collect data and assess the importance of self-regulation and engagement, internet self-efficacy, and course satisfaction in the process of online learning. To fulfill this purpose, the researcher used four questionnaires, namely, the Online Self-regulation Questionnaire, the Online Student Engagement Scale, the Online Learning Self-Efficacy Scale, and the Course Satisfaction Questionnaire. Additionally, the researcher included the reading section of the TOEFL test, with a total of 40 items. These tools were chosen because of their established reliability.

The instruments used in this study were chosen for their robust psychometric properties, as evidenced by prior research, and underwent a rigorous back-translation process to ensure linguistic and cultural appropriateness for Iranian participants. However, further efforts, such as pilot testing and consultation with local experts, ensured that the measures were contextually relevant and accurately captured the constructs being studied.

The online self-regulation questionnaire (OSQ)

The form, created by Cho and Cho [60], included 30 items distributed across three constructs. The initial construct (items 1 to 11) aimed to measure students' interaction with the course materials. The second construct (items 12 to 20) examined students' responsibility in interactions, collaboration, and communication with instructors. The third construct (items 21 to 30) explored students' positive involvement in peer interactions, group discussions, and collective learning. To evaluate participants' responses, a Likert scale with seven points was used. The scale ranged from 1 (representing "not at all true of me") to 7 (representing "very true of me").

The Online Student Engagement Scale (OSE)

The enquiry utilized the Online Student Engagement Scale, developed by Dixson [61]. The scale included 19 statements covering various engagement-related behaviors. Participants had to use a 7-point Likert scale to show how each statement reflected their personal experiences. The scale ranged from 1 (indicating "not at all characteristic of me") to 7 (representing "very characteristic of me").

The questionnaire designer evaluated engagement by categorizing it into four dimensions. The first dimension, Skills examined behaviors such as note-taking. Items 1, 3, 4, 5, 6, and 7 centered around participants' active engagement in acquiring and organizing information. The second dimension, Emotional Engagement, investigated participants' intrinsic motivation and desire to learn. Items 2, 8, 9, 10, 11, and 19 gauged emotional investment, curiosity, and enthusiasm. Participation constituted the third dimension, highlighting involvement in discussions and forums. Items 12, 13, 14, 17, and 18 assessed collaborative learning, idea sharing, and peer interaction. The fourth dimension, Performance, concentrated on achieving high grades. Items 15 and 16 evaluated academic accomplishment and motivation to excel.

The Online Learning Self-Efficacy Scale

Zimmerman and Kulikovich [62] devised the Online Learning Self-Efficacy Scale (OLSES), comprising 22 activities. This scale gauges the respondents’ perceptions of their ability in performing the given tasks, starting from 1 to 6. A score of one reflects low self confidence in performance, a score of 6 shows a strong belief in a one's skills. The total rating ranges from 22 to 132. The dimensions and corresponding items of OLSES are as follows:

- Learning: 11, 12, 13, 14, 15, 17, 18, 19, 21, 22
- Time: 8, 9, 10, 16, 20
- Technology: 1, 2, 3, 4, 5, 6, 7

The Course Satisfaction Questionnaire

In the previously mentioned general English course, students were required to fill in the Course Satisfaction Questionnaire (CSQ) developed by Frey et al. [63]. The CSQ consists of twenty-one items and is rated on a 7-point scale, ranging from 1 (extremely dissatisfactory) to 7(very satisfactory). CSQ scores range from 21 to 147, with higher scores reflecting greater levels of satisfaction with the course. The CSQ encompasses the following components and corresponding items:

- Interaction between students and faculty: 1, 2, 3, 13, 14, 17
- Content relevance: 5, 8, 9, 10, 11, 12, 20
- Teaching/delivery: 4, 6, 7, 15, 16, 18, 19, 21

Reading Comprehension Test

The reading section of the TOEFL was used for assessing students' reading comprehension skills. It covers various micro-skills, including word recall for vocabulary comprehension, understanding word meanings in context. Moreover, the TOEFL reading section focuses on higher-level abilities, such as drawing inferences from the text, identifying synonyms, and effectively searching for specific information. It also evaluates students' proficiency in comprehending references and understanding grammatical relationships within the text. Additionally, the test measures the capability to use skimming and scanning techniques to navigate the text and find relevant information efficiently. Lastly, the section assesses students' ability to recognize the author's style and tone, providing a deeper understanding of the intended message of the text.

Procedure

To assess the proficiency of students in the general English course, the TOEFL reading section was administered to a total of 315 students. The test was conducted online through the university's virtual education system, providing a convenient and accessible platform for student participation. For research purposes, the questionnaires were designed using Google Forms and distributed to these students in autumn 2022.

To ensure the respondents' understanding of the questionnaire items, the researcher utilized Persian versions of the questionnaires. These questionnaires had not been previously published or available in Iranian research journals, so the researcher translated them with the assistance of two professors proficient in both languages. Back translations were conducted to maintain accuracy and precision.

Out of the 315 students who received the questionnaires, 282 students completed and submitted them. However, upon closer examination, it was found that 18 responses exhibited patterns that made them unreliable for analysis. These patterns included consistently selecting the neutral option or choosing the same response for every question. Therefore, these responses were omitted, leaving 264 valid answers for the subsequent examination.

The remaining 264 responses, along with the students' reading comprehension scores, were included in the data analysis. By examining the questionnaire responses and performance on the TOEFL reading section, researchers aimed to gain insights into the relationship between students' self-reported perceptions and their reading comprehension abilities.

Design

The study adopts a descriptive correlational design, aiming to explore the links between regulatory engagement, self-efficacy, course satisfaction, and reading comprehension. This design enables the researcher to discover the relationships between these variables and acquire a more profound comprehension of their characteristics and strengths.

Results and Findings

In this research study, the researcher investigated the levels of self-regulation of learning, classroom engagement, Internet self-efficacy, course satisfaction, and TOEFL reading performance among Iranian students who were taking online classes. Various statistical analyses, such as reliability, correlation, and regression, were carried out. The results are presented here.

Before addressing the research questions, the researcher estimated the reliability of the measurements. The researcher calculated Cronbach's Alpha coefficient for each measure, and the outcomes are described in Table 1. The Cronbach alpha for Self-regulation, Engagement, Self-efficacy, Course satisfaction, and Reading test were .94, .90, .90, .93, and .86, respectively. These coefficients indicate that the instruments are reliable and the items within each measure demonstrate a strong internal consistency.

The assessment included a thorough examination of construct validity as well. This evaluation aimed to determine how effectively the instruments measure the intended constructs. Construct validity offers evidence that the instruments accurately capture the theoretical concepts they were designed to assess. It is worth mentioning that confirmatory factor analysis was employed to evaluate construct validity.

Table 2 reveals the findings on construct validity. The RMSEA quantities for Engagement, Self-regulation, Satisfaction, Self-efficacy, and Reading are estimated as 0.08, 0.07, 0.08, 0.07, and 0.01, respectively. These values indicate satisfactory results. According to Browne and Cudeck [64], models with an RMSEA less than 0.08 and PCLOSE of 0.5 or higher are considered adequate.

With the thorough assessment of the questionnaires and the reading test for their reliability and validity, the researcher can confidently move forward in addressing the research questions central to the study. The first research question is restated here.

-Does learning outcome promote satisfaction as claimed by Marks et al. [59]?

To answer this question, the data were put into a regression equation in which satisfaction was the dependent variable and reading comprehension scores (learning outcome), along with self-regulation, engagement, and self-efficacy, were considered the independent variables. The results are presented in Table 3.

Table 1: Reliability of the instruments

Instruments	Self-regulation	Engagement	Internet Self-efficacy	Course Satisfaction	Reading Comprehension
Cronbach's Alpha	.94	.90	.90	.93	.86
N of items	30	19	22	20	40

Table 2: Model Fit Statistics of the Instruments

Instruments	RMSEA	LO 90	HI 90	PCLOSE
Engagement	.08	.07	.09	.5
Self-regulation	.07	.06	.09	.5
Satisfaction	.08	.07	.09	.5
Self-efficacy	.07	.06	.09	.5
Reading test	.01	.01	.02	1

Table 3: Model Summary of Learning Outcome, Self-regulation, Engagement, Self-efficacy & Course Satisfaction

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.71	.5	.5	10.96	.5	67.16	4	259	.00

The F-statistic (F = (4,259) 67.14, p = 0.00) showed that the model was statistically significant. This means that the connection among learning outcome, self-regulation, engagement, self-efficacy, and course satisfaction is not random. Instead, it indicates a meaningful and reliable association between these variables. The R Square value of .5 suggests that these variables explain 50% of the variance in course satisfaction, which is a noteworthy finding.

Table 4 shows that the Variance Inflation Factor (VIF) indices for the major variables were all below 3.7, indicating that multicollinearity is not a concern. To ensure that the regression model was accurate, the researcher carried out additional diagnostic tests. Attempts were made to find the outliers, but it was noticed that they did not have any significant effects on the findings. The normality assumption was also examined, and the data showed a satisfactory distribution, suggesting that the residuals followed a normal pattern.t4

The results displayed in Table 4, however, indicate that "reading comprehension" does not account for the variation in course satisfaction (t= .23, p= .81). Therefore, these findings do not support the argument made by Marks et al. [59] who claimed that learning outcomes have a significant impact on course satisfaction. This finding highlights the complexity of measuring and understanding the relationship between learning outcomes and student satisfaction.

The researcher utilized standard linear regression to assess the predictive function of engagement, self-efficacy, self-regulation, and satisfaction on learners' reading comprehension. To explore the multicollinearity among the independent variables, their correlation was examined.

Markedly, a coefficient of 0.84 was found between self-regulation and engagement, and a coefficient of 0.7 between self-efficacy and satisfaction (Table 5). According to Pallant's [65] guideline, a bivariate correlation of 0.7 or higher between independent variables can pose challenges when testing and interpreting regression coefficients. Therefore, Pallant recommends forming a 'composite' variable by combining the scores of the two strongly correlated variables.

To create a composite variable, the scores of the two variables underwent a transformation into Z scores. This transformation standardized the data, facilitating meaningful comparisons. It ensured that both variables were placed on the same scale, removing any potential bias originating from differences in their original measurement units. Once the Z scores were obtained, they were combined using a specific statistical procedure described in Tabachnick and Fidell's [66] work. This merging process entailed amalgamating the Z scores from each variable to generate a singular composite score that captured the underlying relationship between the two variables. By integrating the information from both variables into a composite measure, the researcher aimed to get a broader understanding of the phenomenon being investigated. The new variables are:

- "Regulatory Engagement" combines self-regulation and engagement.

- "Satisficacy" merges satisfaction and self-efficacy.

To understand the role of these two composite variables, the researcher used a standard linear regression analysis. According to the F-statistic (F = (2, 261) 46.25, p = 0.00) presented in Table 6, the model demonstrated statistical significance. This implies that the connection between Regulatory Engagement and Satisficacy and their impact on learning outcomes was not random. Rather, it signified a meaningful and dependable association between these variables. The R Square value of .51 indicates that these variables account for 51% of the variation in reading comprehension, which is a significant discovery.

Table 4: Regression Model of Self-efficacy, Self-regulation, Reading test, Engagement & Satisfaction

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	sig.	Tolerance	VIF
1	(Constant)	27.89	8.13		3.42	.00		
	Self-efficacy	.62	.05	.64	11.27	.00	.58	1.71
	Self-regulation	.06	.05	.10	1.27	.2	.26	3.79
	Reading test	.06	.27	.01	.23	.81	.69	1.43
	Engagement	.00	.08	.00	.08	.92	.27	3.6

Table 5: Correlations among Reading Comprehension, Self-efficacy, Self-regulation, Satisfaction & Engagement

		Reading Comprehension	Self-efficacy	Self-regulation	Satisfaction	Engagement
Pearson Correlation	Reading Comprehension		.54	.33	.39	.25
	Self-efficacy			.5	.7	.46
	Self-regulation				.43	.84
	Satisfaction					.4
	N	264	264	264	264	264

Table 6: Model Summary of Regulatory-engagement, Satisficacy & Reading Comprehension

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.51	.26	.25	2.56	.26	46.25	2	261	.00

Predictors: (Constant), regulatory-engagement, Satisficacy

The next step involved assessing whether there were any differences between regulatory engagement and satisficacy in predicting the learning outcome. To tackle with issues of multicollinearity, the Variance Inflation Factor (VIF) indexes were inspected and found to be below 1.34, indicating that multicollinearity was not a significant concern. Upon analyzing the results, the β index for satisficacy was .47 (p = .00), while for regulatory engagement, it was .06 (p = .26). This shows that satisficacy is a statistically significant predictor of the learning outcome, whereas regulatory engagement does not strongly predict the outcome. This finding contrasts with existing literature [22, 11]. Therefore, it can be speculated that regulatory engagement plays an indirect role in predicting the learning outcome. To explore this assumption further, the data is subjected to structural equation modeling analysis, and the researcher poses the following question:

Does satisficacy mediate the relationship between regulatory engagement and reading comprehension?

The model is visually displayed in Figure 1, where it outlines the direct effect of Regulatory Engagement on reading comprehension, as well as the indirect effect of regulatory engagement on reading comprehension through the supposedly mediating factor of satisficacy.

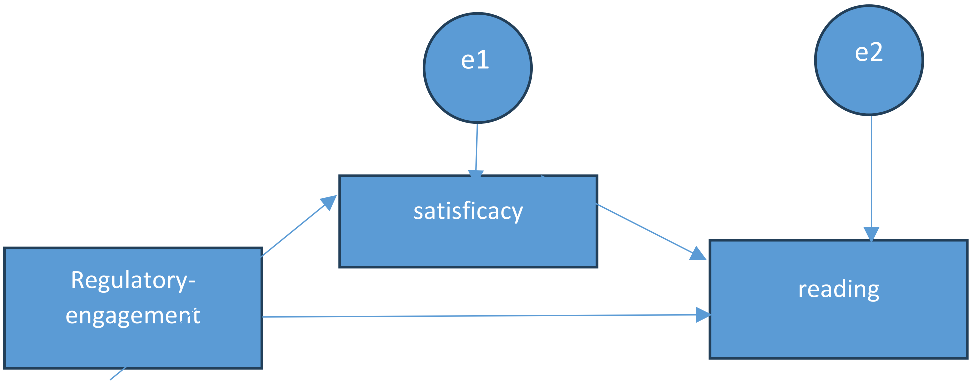

Fig. 1: Full mediation model

To assess the normality of the distribution, an examination was conducted on the skewness and kurtosis values for the variables of regulatory engagement, satisficacy, and reading comprehension. The skewness indices were estimated to be 0.16, -0.15, and -0.53, respectively. Moreover, the parallel kurtosis indexes were realized to be -0.58, -0.80, and 0.14. According to the guidelines outlined by Collier [67], skewness values falling between -2 and +2, as well as kurtosis values ranging from -10 to +10, are indicative of a normal distribution. In light of this, the present dataset can be deemed to adhere to a normal distribution pattern.

However, upon analysis, Root Mean Square Error of Approximation (RMSEA) turned out to be .44 which was way beyond Browne and Cudeck's [64] threshold of .08. Hence, the full mediating model was not confirmed as a significant pathway between the predictor (Regulatory Engagement) and the outcome (reading comprehension). This means that the initial model failed to provide evidence in support of the hypothesis. Subsequently, further inspection was required to establish an alternative model that could account for the relationship between the variables under investigation.

Figure 2 below depicts the alternative partial mediation model. The accompanying results are presented subsequently.

The default model yields a chi-square test statistic of 1.24, corresponding to 1 degree of freedom and a probability level of .26. This finding indicates a satisfactory association between the model and the obtained data, as the p-value exceeds the conventional significance level of .05. Furthermore, additional fit indicators, including the RMSEA at .03, further support the notion of a favorable model fit, given that it falls below the recommended threshold of .08 [64]. Within the model, multiple paths connecting variables have been incorporated. Specifically, it has been determined that satisficacy exerts a positive influence on regulatory engagement, with an estimated effect size of .47 and a critical ratio (C.R.) of 9.57. Likewise, satisficacy is found to positively impact reading comprehension, as indicated by an estimated effect size of .81 and a critical ratio (C.R.) of 9.56.

The results of the analysis offer compelling support for the presence of a noteworthy indirect (mediated) effect of regulatory engagement on reading comprehension. Particularly, the coefficient obtained from the analysis stands at 0.39, with a corresponding p-value of 0.01. This coefficient signifies that with each incremental increase of one unit in regulatory engagement, there is an associated improvement in reading performance by 0.39 units.

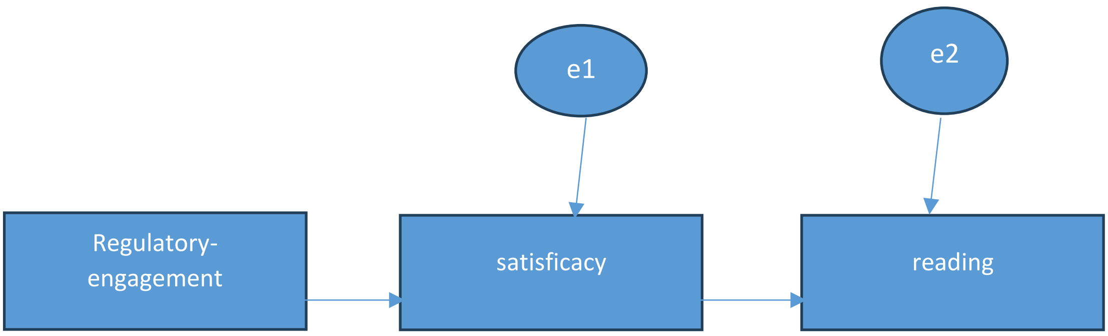

Fig. 2: Partial mediation model

To determine the strength of the above-mentioned coefficient, a bootstrap analysis was carried out, producing a lower bound value of 0.30 and an upper bound value of 0.48. It is notable that the estimated effect of 0.39 falls within this range. This consistency reinforces the conclusion that the indirect effect of regulatory engagement on reading comprehension is indeed statistically significant.

Furthermore, these findings suggest that the relationship between regulatory engagement and reading comprehension is fully mediated by the construct of satisficacy. This construct encompasses both satisfaction and self-efficacy, highlighting the interplay between subjective contentment and perceived competence in relation to regulatory engagement and its influence on reading comprehension. In essence, the impact of regulatory engagement on reading comprehension is dependent on its influence on satisficacy, emphasizing the pivotal role played by this psychological construct in translating regulatory engagement into enhanced reading abilities.)

Discussion

The present study investigated the relationship between self-regulation of learning, classroom engagement, internet self-efficacy, course satisfaction, and reading performance in online courses in the context of Iran. Statistical analyses highlighted important relationships among these variables while raising intriguing questions about their implications, applications, and broader significance. The findings of this study revealed significant insights into the dynamics of online learning. Notably, while self-regulation, engagement, and self-efficacy collectively accounted for 50% of the variance in course satisfaction (Table 3), reading comprehension did not emerge as a significant predictor of course satisfaction (Table 4). This result diverges from Marks et al. [59], who suggested a direct and substantial link between learning outcomes and satisfaction. Instead, our findings suggest that satisfaction may stem from other aspects of the learning experience, such as engagement, instructional quality, and student motivation, rather than reading comprehension alone. This discrepancy underscores the complex and context-specific nature of these constructs, warranting further exploration in varied cultural and educational settings.

It should be mentioned that our findings are context-specific and pertain to the particular dataset and methodology employed in the study. However, they do provide valuable insights that cast doubt on the previously established notion of a significant relationship between reading comprehension and course satisfaction, as proposed by Marks et al. [59].

Moreover, the correlation between learning outcomes and student satisfaction may vary across different branches of learning, courses, and individual learners. Certain subjects or instructional approaches may prioritize different aspects of learning that do not directly align with traditional learning outcomes. These variations can affect the generalizability of the findings and the applicability of using student achievement as a sole indicator of instructional effectiveness.

In conclusion, while Marks et al. [59] suggest a link between student satisfaction and learning outcomes, it is important to interpret their findings in the appropriate context. Student satisfaction is a complex construct influenced by multiple factors, and relying solely on student achievement as a measure of course effectiveness may oversimplify the overall picture. A comprehensive understanding of student satisfaction requires considering a broader range of variables and adopting a more nuanced approach.

As shown in Table 6, students' levels of regulatory engagement (their active involvement, goal setting, and self-monitoring in the learning process) and satisficacy (their satisfaction with the course and perception of meeting the necessary requirements for successful learning) are influential factors in promoting their reading comprehension abilities. Although this piece of finding is significant, its generalizability should be deliberated. This study focused specifically on reading comprehension, and its applicability to other subject areas or educational contexts may vary.

When satisficacy and regulatory engagement are jointly taken into account, they emerge as statistically significant predictors of learning outcomes (Table 7). This implies that both of these factors, when considered together, exert a meaningful influence on the final learning outcomes achieved by individuals. However, it is essential to note that the major contributor to learning outcomes appears to be satisficacy, as it demonstrates a stronger predictive capacity compared to regulatory engagement in isolation. In other words, people with a high level of satisfaction are more likely to achieve favorable learning outcomes. On the contrary, the predictive power of regulatory engagement, when examined independently, does not exhibit a robust association with learning outcomes. This unexpected observation challenges the prevailing literature [5-9,11] and calls for a deeper understanding of the intricate interplay between satisficacy, regulatory engagement, and learning outcomes. To clarify this complex relationship, the present study investigated the structural relationship between these variables. It was found that increase in regulatory engagement was associated with improvement in reading performance.

These findings have significant theoretical implications. First, they challenge the conventional assumption that student achievement is a primary determinant of satisfaction in online learning. Instead, the study suggests that factors such as self-regulation and satisficacy play a more critical role. This calls for a shift in research focus from a one-dimensional view of satisfaction as an outcome of learning to a broader, multidimensional perspective that considers other psychological and behavioral factors.

The partial mediation model, as displayed in Figure 2, reveals that the model fit is highly favorable. These findings offer conclusive evidence to support the existence of a significant indirect effect of regulatory engagement on reading comprehension, with satisficacy acting as a crucial mediating factor. Satisficacy, a construct that amalgamates satisfaction and self-efficacy, plays a pivotal role in facilitating the translation of regulatory engagement into improved reading abilities. In essence, regulatory engagement influences reading comprehension indirectly by exerting its impact through satisficacy. This implies that individuals who exhibit higher levels of regulatory engagement are more likely to experience greater satisficacy, which in turn fuels their enhanced reading comprehension skills. By uncovering this mediating mechanism, the study sheds light on the intricate relationship between regulatory engagement, satisficacy, and reading comprehension, thus expanding our understanding of the cognitive processes involved in achieving optimal levels of reading proficiency. Educators should recognize that simply fostering self-regulation may not be enough; ensuring that students feel confident and satisfied with their learning process is equally important.

From a practical standpoint, these findings emphasize the importance of designing online courses that actively promote both regulatory engagement and satisficacy. This could be achieved by incorporating strategies that enhance students' self-efficacy, motivation, and satisfaction, ultimately leading to improved learning outcomes.

Our study diverges from previous research that suggests a direct correlation between learning outcomes and satisfaction [59]. One possible explanation for this discrepancy is the varying nature of student experiences across different learning environments. In traditional classroom settings, where instructor support and peer interactions are more immediate, learning achievements may translate more directly into satisfaction. However, in online settings, satisfaction may be influenced by additional factors such as technology use, self-efficacy, and the availability of support mechanisms.

Additionally, while studies like Richardson and Swan [54] and Eom and Ashill [51] argue that satisfaction is a predictor of academic success, our findings suggest that satisficacy, rather than satisfaction alone, is a more meaningful predictor. This distinction underscores the importance of considering self-efficacy and regulatory engagement alongside satisfaction when evaluating online learning experiences.

Based on findings of this study, several practical strategies can be implemented to enhance student engagement, satisfaction, and learning outcomes in online education:

- Set Clear Goals and Expectations: Encourage students to establish clear learning goals and expectations at the beginning of the course. This helps them stay focused, motivated, and engaged throughout the online learning experience [13].

- Encourage Instructor-Student Interaction: Promote regular interaction between instructors and students through discussion forums, virtual office hours, and personalized feedback. This interaction builds a sense of community and encourages students to actively participate and engage with the course material [17, 20].

- Provide Structured Learning Resources: Offer well-organized and easily accessible learning resources, such as lecture recordings, readings, and interactive multimedia materials. Structured resources enable students to navigate the course content effectively, leading to a better understanding of the subject matter [38].

- Develop Time Management Skills: Emphasize the importance of effective time management for online learning. Encourage students to create schedules, set deadlines, and allocate dedicated study time to balance their coursework effectively. This promotes a sense of control and helps students stay on track [13].

- Provide Internet Skills Training: Offer tutorials or workshops on internet skills and online learning platforms to enhance students' internet self-efficacy. Teach essential digital literacy skills, such as online research, effective communication in virtual environments, and online collaboration tools [61].

- Promote Peer Interaction and Collaboration: Facilitate opportunities for students to engage in peer to-peer interaction and collaboration. This can be done through group projects, online discussions, or virtual study groups, promoting shared knowledge construction and enhancing the sense of community in the online class [20].

- Incorporate Varied Assessment Methods: Utilize diverse assessment methods to cater to different learning styles and provide students with a variety of opportunities to demonstrate their knowledge and skills. This can include quizzes, essays, group presentations, and online discussions [61].

- Collect and Utilize Feedback: Actively gather feedback from students regarding their learning experience to identify areas for improvement. Use this feedback to make necessary adjustments to the course design, content delivery, or engagement strategies, thereby enhancing overall course satisfaction [36].

- Foster a Positive Learning Environment: Create a positive and inclusive learning environment by valuing student contributions, encouraging active participation, and providing constructive feedback. This fosters a sense of belonging and motivates students to actively participate in the learning process [48].

- Promote Continuous Reflection and Self-Assessment: Encourage students to reflect on their learning progress and engage in self-assessment activities. This helps them identify areas of strength and areas that require further improvement, fostering self-regulation and self-directed learning [39].

By implementing these techniques, instructors can enhance regulatory engagement, internet self-efficacy, and course satisfaction among students, ultimately leading to improved learning outcomes in online classes.

Conclusions

The study found that satisficacy, a composite variable combining satisfaction and self-efficacy, was a significant predictor of the learning outcome, while regulatory engagement did not strongly predict the outcome. However, further analysis using structural equation modeling revealed an indirect effect of regulatory engagement on reading comprehension through the mediating factor of satisficacy. This suggests that the impact of regulatory engagement on reading comprehension is dependent upon its influence on satisficacy. These findings have implications for educational practitioners and researchers in understanding the multifaceted nature of student learning and satisfaction. It emphasizes the significance of fostering regulatory engagement to enhance satisfaction and self-efficacy thereby promoting reading comprehension.

This study has its limitations. The data analyzed was based on a specific context and sample, which may limit its generalizability to other settings. Additionally, the composite variables created may introduce complexities and require further validation in different contexts.

Future research should explore the nuanced relationships between regulatory engagement, satisficacy, and reading comprehension, as well as their influence on other subject areas. Additionally, future studies can examine the role of external factors, such as technological challenges, instructor presence, and institutional support, in shaping student satisfaction in online learning. Longitudinal research would be beneficial in assessing how internet self-efficacy and regulatory engagement evolve over time and their long-term impact on academic success. Moreover, investigating the effectiveness of various instructional strategies, including gamification, interactive multimedia, and adaptive learning systems, could provide valuable insights into enhancing satisficacy and improving student outcomes.

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Conflict of Interest

The author has no personal or financial interests that could potentially influence this work.

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ORIGINAL RESEARCH PAPER

Self-Efficacy and Self-Regulation in EFL Teachers: The Role of MALL and ICT Engagement

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ABSTRACT

Background and Objectives: The rapid advancement of technology has not just significantly transformed, but revolutionized language education by integrating Information and Communication Technology (ICT) and Mobile-Assisted Language Learning (MALL). These tools, far from just enhancing, have completely redefined language learning by making it more interactive and accessible. However, their successful implementation depends on teachers' proficiency and confidence in using them. In Iran, where English as a Foreign Language (EFL) instruction is crucial for students' academic success, understanding the factors influencing teachers' engagement with ICT and MALL is essential. Self-efficacy, or the belief in one's ability to succeed, and self-regulation, which involves goal-setting and monitoring progress, are critical for teachers as they adopt new instructional methods. Recent research indicates that self- efficacy and self-regulation are important for how teachers master their practice. Despite the presence of enough literature on online learning and teaching, however, there is little research examining the relationship between teachers' self-efficacy and self-regulation and their knowledge of MALL and ICT engagement. In this study Self-efficacy and self-regulation were chosen as key constructs in exploring MALL and ICT due to their significant impact on teachers' success in language teaching. This study aims to address the relationship between EFL teachers' knowledge of ICT and MALL with their self-efficacy and self- regulation. The study also sought to explore EFL teachers' attitudes and opinions regarding MALL, ICT knowledge, and their effects on developing teachers' traits.

Materials and Methods: The research employed a mixed-methods design of two phases which enriches the findings, allowing for a more nuanced interpretation of the results and better addressing the complexity of the research question. The quantitative phase involved 120 EFL teachers. They were chosen by convenience sampling from private language centers in Tehran. The participants needed to complete three scales in self-efficacy devised by Smith and Betz's (2000), self-regulation articulated by Miller and Brown (1991), and ICT and MALL engagement (Zylka et al., 2015). The collected data were analyzed using descriptive statistics to identify significant relationships between variables. Moreover, Pearson product-moment correlation coefficient was run to find the correlation coefficient between the variables of the study. The qualitative phase included structured interviews with 20 teachers that were randomly selected to gain deeper insights into their experiences. The qualitative data and interview results were extracted and analyzed manually to identify common themes and patterns in the participants' responses, enriching the overall understanding of their engagement with technology in language instruction.

Findings: The results indicate a positive correlation between teachers' knowledge of ICT and MALL and their self-efficacy and self-regulation. Quantitative analysis revealed that teachers proficient in digital technologies and mobile applications for language learning demonstrated higher confidence and effective self-regulatory strategies. Qualitative insights from structured interviews confirmed teachers' strong understanding of ICT and MALL, highlighting how technology engagement enhanced lesson planning, classroom management, and teaching effectiveness. This combination of quantitative and qualitative data underscores the significant relationship between teachers' technological competencies, self-beliefs, and self-regulatory practices.

Conclusions: The study indicates that teachers' MALL and ICT knowledge is associated with their self –efficacy and self- regulation. It concludes that teachers' use of ICT in teaching practice can be facilitated by their ICT self-efficacy for instructional purposes. It emphasizes the importance of increasing ICT proficiency among educators and underscores technology's critical role in language instruction. Ongoing professional development should focus on integrating ICT and MALL into practices, boosting teachers' confidence and self-regulation for more effective learning environments. The findings suggest tailored support systems for Iranian EFL teachers to improve language education, ensuring that educators adapt their methods to meet the linguistic demands of the 21st century. The use of convenience sampling and a focus on private language centers in Tehran may restrict the generalizability of the study's results. Future research should aim for a more diverse sample across different locations and educational settings to improve the applicability of the findings.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
42	2	7

مقاله پژوهشی

بررسی رابطه‌ی بین دانش معلمان زبان انگلیسی در زمینه فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه با خودکارآمدی و خودتنظیمی آن‌ها

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چکیده

پیشینه و اهداف: پیشرفت سریع فناوری نه تنها به طور قابل توجهی آموزش زبان را متحول کرده، بلکه با ادغام فناوری اطلاعات و ارتباطات با یادگیری زبان به کمک تلفن همراه، آن را دچار انقلاب کرده است. این ابزارها نه تنها به بهبود یادگیری زبان کمک می‌کنند، بلکه آن را به طور کامل بازتعریف کرده و آن را تعاملی‌تر و در دسترس‌تر کرده‌اند. با این حال، اجرای موفق این فناوری‌ها به مهارت و اعتماد به نفس معلمان در استفاده از آن‌ها بستگی دارد. در ایران، جایی که آموزش زبان انگلیسی به عنوان زبان خارجی برای موفقیت تحصیلی دانش‌آموزان حیاتی است، درک عواملی که بر درگیری معلمان با فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه تأثیر می‌گذارد، ضروری است. خودکارآمدی، یا باور به توانایی فرد در موفقیت، و خودتنظیمی، که شامل تعیین هدف و نظارت بر پیشرفت است، برای معلمان هنگام پذیرش روش‌های جدید آموزشی، ضروری است. این مطالعه به بررسی رابطه بین دانش معلمان زبان انگلیسیِ ایرانی در زمینه فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه با خودکارآمدی و خودتنظیمی آن‌ها می‌پردازد. هدف این مطالعه، ارائه بینش‌هایی است که می‌تواند برنامه‌های توسعه حرفه‌ای را اطلاع‌رسانی کرده و کیفیت آموزش زبان را ارتقا دهد.

روش‌ها: این تحقیق از یک روش ترکیبی شامل دو مرحله استفاده کرده است. مرحله کمی شامل ۱۲۰ معلم ایرانیِ زبان انگلیسی از مراکز آموزش زبان خصوصی در تهران بود که پرسشنامه‌های معتبر برخط را در زمینه خودکارآمدی، خودتنظیمی و درگیری با فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه تکمیل کردند. داده‌های جمع‌آوری شده با استفاده از نرم‌افزارهای آماری تحلیل شدند تا روابط معناداری بین متغیرها شناسایی شود. مرحله کیفی شامل مصاحبه‌های ساختاریافته با ۲۰ معلم بود تا بینش‌های عمیق‌تری از تجربیات آن‌ها به دست آید. این مصاحبه‌ها در یک محیط خصوصی انجام شد و به شرکت‌کنندگان اجازه داد تا افکار خود را در مورد ادغام فناوری در تدریس خود به اشتراک بگذارند.

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واژگان کلیدی:
خودکارآمدی معلم زبان انگلیسی
خودتنظیمی معلم زبان انگلیسی
فناوری اطلاعات و ارتباطات یادگیری زبان به کمک تلفن همراه

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داده‌های کیفی به صورت متنی درآمده و به صورت موضوعی تحلیل شدند تا الگوها و مضامین مشترک در پاسخ‌های شرکت‌کنندگان شناسایی شوند و درک کلی از درگیری آن‌ها با فناوری در آموزش زبان غنی‌تر شود.

یافته‌ها: نتایج نشان‌دهنده یک همبستگی مثبت بین دانش معلمان در زمینه فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه و خودکارآمدی و خودتنظیمی آن‌ها است. تحلیل‌های کمی نشان داد که معلمان ماهر در فناوری‌های دیجیتال و برنامه‌های تلفن همراه برای یادگیری زبان، اعتماد به نفس بالاتر و راهبردهای خودتنظیمی مؤثرتری را نشان می‌دهند. بینش‌های کیفی به دست آمده از مصاحبه‌های ساختاریافته این یافته‌ها را بیشتر تأیید کرد و نشان داد که بهره مندی از فناوری برنامه‌ریزی درسی، مدیریت کلاس و اثربخشی تدریس را بهبود می‌بخشد. ترکیب داده‌های کمی و کیفی بر رابطه معناداری بین مهارت‌های فناوری معلمان، باورهای خود و شیوه‌های خودتنظیمی، تأکید می‌کند.

نتیجه‌گیری: این مطالعه نتیجه‌گیری می‌کند که افزایش دانش در زمینه فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه به طور قابل توجهی پیش‌بینی‌کننده خودکارآمدی و خودتنظیمی معلمان زبان انگلیسی است. این موضوع ضرورت پرداختن به موانع یادگیری برخط برای بهبود کیفیت تدریس را تأکید کرده و اهمیت افزایش مهارت‌های فناوری اطلاعات و ارتباطات در میان معلمان زبان انگلیسی را روشن می‌سازد. یافته‌ها نقش حیاتی فناوری در آموزش زبان مدرن و ضرورت توسعه حرفه‌ای مداوم را که بر ادغام فناوری اطلاعات و ارتباطات و یادگیری زبان به کمک تلفن همراه در شیوه‌های آموزشی تمرکز دارد، نشان می‌دهد. با تقویت خودکارآمدی و خودتنظیمی معلمان در استفاده از این فناوری‌ها، مؤسسات آموزشی می‌توانند محیط‌های یادگیری جذاب‌تر و مؤثرتری برای دانش‌آموزان ایجاد کنند. به‌ویژه، این یافته‌ها پیشنهاد می‌کنند که برنامه‌های توسعه حرفه‌ای باید بر افزایش مهارت‌های فناوری معلمان، تقویت باورهای خود و ترویج شیوه‌های خودتنظیمی تمرکز کنند. علاوه بر این، بینش‌های به‌دست‌آمده از این تحقیق می‌تواند به توسعه سیستم‌های حمایتی متناسب برای معلمان زبان انگلیسی ایرانی کمک کند و در نهایت به بهبود آموزش زبان در کشور منجر شود. با پیشرفت فناوری، معلمان باید روش‌های خود را تطبیق دهند تا دانش‌آموزان را برای نیازهای زبانی قرن بیست و یکم آماده کنند.

Introduction

Today, in the context of rapid technological advancements and the increasing connections between learners and teachers, the introduction of modern digital devices into classrooms has paved the way for mobile-assisted language learning (MALL) and computer-mediated communication (CMC). These developments hold a vast potential to significantly impact language learning and teaching [1]. As schools prepare students to live in a technology- infused society and technology–driven workplaces, we must have teachers who are well prepared to support students' learning through the use of technology. It is widely recognized that teachers play a significant role in the classroom integration of ICT [2]. Therefore, while previous research on the integration of ICT has largely focused on students' outcomes, recent studies have made a significant shift in focus to the growth of teachers' knowledge in this area, keeping the audience informed and up-to-date [3].

A good teacher can improve a student's life. Relationships between teachers and students are essential to their success [4]. Interaction and communication between individuals, as well as interaction with ICT-based instructional tools, may influence knowledge sharing in terms of MALL and ICT engagement and the level of effective factors like self-regulation and self-efficacy [5].

Self-efficacy, characterized as a person's confidence in his ability to regulate his thoughts, feelings, and behaviors and influence an outcome, is a critical component in Banduras' (1997) [6] social cognitive learning theory. Teachers with high self-efficacy are more likely to implement innovative teaching strategies, engage in professional development, and foster positive learning environments, which ultimately leads to improved student achievement [7]. Conversely, teachers with low self-efficacy may experience increased stress, burnout, and a reluctance to embrace new teaching methodologies [8]. Research has consistently shown that self-efficacy is a strong predictor of teacher performance and job satisfaction, as it influences their motivation to set challenging goals and persist in the face of difficulties [9]. Furthermore, enhancing teachers' self-efficacy can lead to a more positive school climate, as confident teachers are better equipped to inspire and motivate their students [10]. Therefore, fostering self-efficacy among educators should be a priority for school leaders and policymakers aiming to improve educational outcomes [8].

Self-regulation, the ability to manage one's thoughts, feelings, and actions to pursue specific goals, is pivotal in academic success [11]. Research indicates that self-regulation is closely linked to students' achievement and motivation within educational contexts, and this relationship extends beyond students to encompass teachers as well [11]. Cardelle-Elawar et al. (2007) [12] assert that effective teachers exemplify self-regulation, perceiving themselves as educators while maintaining motivation amidst diverse responsibilities, student needs, and changing circumstances. Furthermore, self-regulation enables teachers to cultivate a deeper awareness of instructional methodologies and a more nuanced understanding of their students' requirements and learning experiences [13]. This understanding underscores the importance of self-regulation in fostering a supportive learning environment and in promoting student and teacher effectiveness in educational settings [14].

Online instruction is a course designed for learners who do not attend traditional classes and involves distance learning [15]. Research shows that online instruction, as an active learning environment, is highly advantageous since it can provide learners with various levels or types of cognitive and metacognitive activities during the learning process [16]. It is argued that learners can improve their learning when they are involved in processing and reflecting on the learning content [17]. Notably, a bulk of research was conducted in L2 learning integrated with different aspects of affective and social factors [18]. Despite the presence of enough literature on online learning and teaching, however, there is little research examining the relationship between teachers' self-efficacy and self-regulation and their knowledge of MALL and ICT engagement [19]. There is a need to gather knowledge about how different variables interact and are associated with both teachers' ICT self-efficacy for educational purposes and with the use of ICT in their teaching practice.

Investigating the relationship between Iranian EFL teachers' engagement with MALL and ICT and their self-efficacy and self-regulation stems from the increasing importance of technology in contemporary education. As language teaching evolves in response to digital advancements, understanding how teachers interact with these tools is crucial for fostering effective pedagogical practices. MALL and ICT not only provide innovative avenues for language instruction but also require educators to adapt their teaching methodologies and embrace new learning paradigms. By exploring the interplay between teachers' self-efficacy—their belief in their ability to successfully implement these technologies—and their self-regulation skills, which encompass goal-setting, monitoring, and reflective practices, this research aims to shed light on the factors that contribute to successful technology integration in the classroom.

Ultimately, this study seeks to inform professional development initiatives that empower Iranian EFL teachers to enhance their teaching effectiveness and improve student learning outcomes in an increasingly digital world.

The current study is a comprehensive exploration of the perceptions of EFL teachers on teaching in MALL settings and their familiarity with ICT and MALL. In the context of the increasing importance of online instruction in the era of ICT, the study aimed to examine the relationship between the self-efficacy of EFL teachers and their knowledge of MALL and ICT. However, the study's main focus was to understand the intricate interplay between the variables of MALL, self-efficacy, and self-regulation from the teachers' perspective. The study also sought to determine how EFL teachers' self-regulation and knowledge of MALL and ICT interacted. Finally, the study explored EFL teachers' attitudes and opinions regarding MALL, ICT knowledge, and their effects on developing teachers' traits, adding depth and insight to the research.

The following research questions were attempted to be answered in light of the study's purpose:

RQ1: Is there any relationship between EFL teachers' ICT knowledge and MALL and their self-efficacy?

RQ2: Is there any relationship between EFL teachers' ICT knowledge and MALL and their self-regulation?

RQ3: What are the perceptions of EFL teachers about ICT knowledge and MALL and their improvement in teaching English?

Review of the Related Literature

The integration of Mobile-Assisted Language Learning (MALL) and Information and Communication Technology (ICT) in English as a Foreign Language (EFL) contexts has garnered significant attention in recent years [1]. This literature review examines the relationship between MALL and ICT engagement with teachers' self-efficacy and self-regulation, drawing on six relevant studies.

Theoretical Background

The relationship between teachers' self-efficacy regarding Information and Communication Technology (ICT) and their actual use of these tools in instructional settings is a critical area of research, particularly as educational environments increasingly integrate technology. Bandura's (1997) framework on self-efficacy highlights the importance of individual beliefs in their capabilities to perform specific tasks, which directly influences their persistence, motivation, and overall performance. Research indicates that enhancing teachers' self-efficacy in using ICT can lead to more frequent and effective technology integration in their teaching practices. For instance, studies by Fanni et al. (2013) and Teo (2014) demonstrate that higher levels of computer self-efficacy correlate with increased confidence in utilizing ICT for educational purposes. Conversely, lower self-efficacy is associated with infrequent use of these technologies [19]. This suggests that teachers who feel competent in their ICT skills are more likely to incorporate these tools into their teaching, thereby enhancing the learning experience for their students. Krumsvik (2014) emphasizes the distinction between general ICT self-efficacy—confidence in using technology—and ICT self-efficacy for instructional purposes, which pertains specifically to using technology effectively in a teaching context [17]. This distinction is important because, as noted by Scherer and Siddiq (2015), while general ICT self-efficacy may be a prerequisite for instructional self-efficacy, it does not guarantee effective pedagogical application. Teachers need both the skills and the confidence to integrate technology into their teaching effectively. Moreover, Bandura identifies four key influences on self-efficacy beliefs: vicarious experiences, verbal persuasion, physiological arousal, and mastery experiences. In this context, collegial collaboration can provide vicarious experiences through observing peers successfully using ICT, as well as verbal support that reinforces teachers' confidence. Conversely, a lack of support or facilitation from school management can hinder the development of ICT self-efficacy for instructional purposes. In summary, there is a clear link between teachers' general ICT self-efficacy and their confidence in using these tools for instructional purposes. Additionally, contextual factors such as collegial support and administrative facilitation play significant roles in shaping teachers' beliefs and practices regarding technology use in education. Future research should continue to explore these relationships to develop effective professional development programs that enhance teachers' competencies and confidence in integrating ICT into their teaching [15].

The integration of Information and Communication Technology (ICT) and Mobile-Assisted Language Learning (MALL) into English as a Foreign Language (EFL) education has become increasingly significant, particularly in the context of Iranian education. MALL, which uses mobile technologies for language learning, offers unique opportunities to enhance student engagement and facilitate learning beyond traditional classroom environments. Research indicates that MALL can promote collaborative learning, foster self-study, and increase learners' motivation and self-efficacy, making it a valuable tool in modern language education [20]. Despite the potential benefits of MALL, Iranian EFL teachers often encounter challenges in its implementation. Dashtestani (2013) found that many teachers moderately understand MALL and ICT but need more skills and confidence to integrate these technologies into their teaching practices effectively [21]. This gap in technological proficiency highlights the importance of self-efficacy, which refers to teachers' beliefs in their capabilities to execute tasks effectively. Self-efficacy has been linked to positive teaching outcomes, including increased motivation and student engagement [22]. Self-regulation, another critical factor, involves teachers' abilities to set goals, monitor their progress, and adjust their strategies in response to challenges. Research indicates that self-regulated teachers are more likely to adopt innovative teaching methods and engage in continuous professional development [23]. The relationship between EFL teachers' self-efficacy, self-regulation, and engagement with ICT and MALL is pivotal for understanding how to enhance language instruction in Iran. By investigating these interconnections, this study aims to provide insights that can inform professional development programs and educational policies, ultimately improving the quality of EFL education.

Previous Research

Kukulska-Hulme and Shield (2008) explored the implications of mobile learning for language education, emphasizing the potential of mobile technologies to enhance language learning experiences. Their study found that teachers who engaged with MALL reported increased self-efficacy in their teaching practices. The researchers highlighted that mobile tools not only facilitated access to language resources but also fostered a sense of autonomy among teachers, thereby enhancing their self-regulation skills. The findings suggested that teachers who embraced mobile technologies were more confident in their ability to integrate these tools into their pedagogy [24].

Tondeur et al. (2017) investigated the role of ICT in teacher education and its impact on self-efficacy and self-regulation. Their study revealed that teachers who received training in ICT integration exhibited higher levels of self-efficacy compared to those who did not. The authors argued that effective ICT training equips teachers with the necessary skills to utilize technology in their classrooms, which in turn enhances their self-regulatory abilities. The study emphasized the importance of ongoing professional development to sustain teachers' engagement with ICT and improve their instructional practices [25].

Zheng et al. (2016) conducted a meta-analysis examining the relationship between teachers' technological pedagogical content knowledge (TPACK) and their self-efficacy in using technology for language instruction. The results indicated a strong positive correlation between TPACK and self-efficacy. Teachers with higher TPACK were more likely to engage with MALL and ICT tools effectively, which contributed to improved self-regulation in lesson planning and execution. This study underscored the necessity of integrating technology training into teacher education programs to bolster both self-efficacy and self-regulation [26].

Baker and McCulloch (2020) focused on the impact of mobile applications on EFL teachers' professional development and self-efficacy. Their qualitative study highlighted that teachers who utilized mobile applications for language teaching felt more competent in their instructional strategies. The findings suggested that MALL not only enhanced teachers' engagement with technology but also fostered a reflective practice that improved their self-regulation skills. The authors concluded that mobile applications serve as valuable resources for professional growth, leading to increased confidence in teaching [27].

Deng and Tavares (2019) examined the relationship between teachers' ICT usage and their self-efficacy in a large-scale survey involving EFL educators. Their results indicated that frequent ICT use was positively associated with higher self-efficacy levels. The study also found that teachers who engaged with MALL reported better self-regulatory practices, such as goal-setting and self-monitoring of their teaching performance. The authors emphasized the need for supportive school environments that encourage ICT adoption to enhance teachers' confidence and regulatory capabilities [28].

Hwang and Chang (2018) investigated the effects of mobile learning environments on EFL teachers' self-efficacy and motivation. Their experimental study revealed that teachers who participated in mobile learning workshops showed significant improvements in both self-efficacy and self-regulation compared to a control group. The authors concluded that structured exposure to MALL could empower teachers, enabling them to adopt innovative teaching methodologies while fostering a growth mindset towards technology integration [27].

In recent years, the integration of Mobile-Assisted Language Learning (MALL) and Information and Communication Technology (ICT) has gained traction in the context of English as a Foreign Language (EFL) teaching in Iran. Research indicates that MALL can significantly enhance language learning by providing learners with flexible and accessible resources, thus fostering a more engaging learning environment. Iranian EFL teachers' engagement with MALL and ICT is crucial, as it not only impacts their teaching effectiveness but also influences students' learning outcomes. Studies have shown that teachers' self-efficacy—their belief in their ability to effectively use technology—plays a vital role in their willingness to adopt these tools. In the Iranian context, where traditional teaching methods have been predominant, enhancing teachers' self-efficacy regarding MALL and ICT is essential for successful technology integration in language instruction (Gholami Zarei, 2019). Moreover, self-regulation, which refers to an individual's ability to manage their own learning processes, is another critical factor influencing Iranian EFL teachers' engagement with MALL and ICT [29]. Research by Panahandeh and Khoshsaligheh (2018) highlights that teachers who demonstrate higher levels of self-regulation are more likely to engage with innovative technologies and adapt their teaching practices accordingly. This interplay between self-efficacy, self-regulation, and technology engagement suggests that professional development programs aimed at Iranian EFL teachers should focus on enhancing both their confidence in using MALL and ICT and their ability to self-regulate their learning and teaching processes. By fostering these attributes, educators can improve their pedagogical practices and better support their students' language acquisition in an increasingly digital world [30].

The reviewed literature consistently indicates a positive relationship between MALL and ICT engagement with EFL teachers' self-efficacy and self-regulation. These studies underscore the importance of professional development, training, and supportive environments in enhancing teachers' confidence and regulatory skills when integrating technology into language instruction. As the educational landscape continues to evolve, further research is needed to explore these relationships within diverse cultural contexts, particularly focusing on Iranian EFL educators.

Method

Participants

The study focused on the entire EFL teaching staff of private language schools in Tehran, Iran, comprising a sample of 120 EFL teachers selected through convenience sampling. They were contacted through their institutions. The participating teachers were informed about the study's purpose and assured that their personal information would be kept confidential, with only their anonymous comments used in any eventual publication. Demographic data were collected through the initial questionnaire, revealing that 35.3% of the teachers were male and 64.7% were female. Regarding academic qualifications, 61.8% held a Master's degree, 14.7% had a Bachelor's degree, 8.8% were PhD holders, and 14.7% were PhD candidates. Additionally, 85.3% of the teachers had majored in English Language Teaching (ELT), 8.8% in translation studies, and 6.7% in fields unrelated to English teaching. The questionnaire also gathered information on teaching experience, indicating that more than half of the participants had fewer than ten years of teaching experience, while 41% had over ten years. Overall, the teachers had a minimum of four years of experience teaching English, with ages ranging from 26 to 59.

From the total, 85.3% of the teachers had majored in ELT, 8.8% in translation studies, and 6.7% were majoring in fields not related to English teaching (See Figure 1).

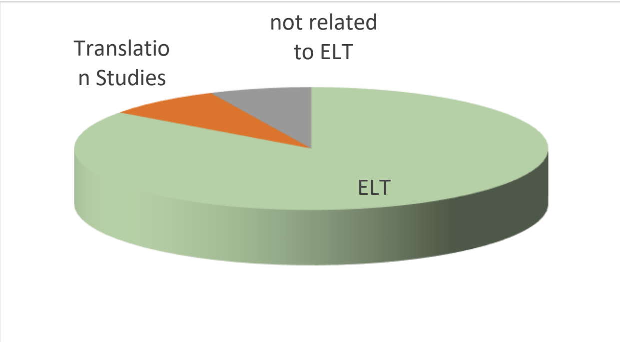

Fig. 1: Rates of majors

Materials and Instruments

Self-efficacy Scale

The first instrument used was the social self-efficacy scale (PSSE) developed by Smith and Betz in 2000 [26]. This comprehensive questionnaire consists of a 25-item 5-point Likert scale and covers a wide range of social situations, such as making friends and giving and receiving help. Smith and Betz (2000) [25] found that the PSSE scale had a single-factor structure. The total score on the scale ranges from 25 to 125, with higher scores indicating higher levels of social self-efficacy. The reliability of the scale was estimated to be 0.84 using Cronbach's alpha.

Self-regulation Questionnaire

The Self-Regulation Questionnaire (SRQ) was utilized in this study to assess the seven sub-processes of self-regulation as defined by Miller and Brown (1991) [31]. This 63-item self-report instrument is designed to evaluate the following sub-processes: receiving relevant information, evaluating that information against norms, triggering change, searching for options, formulating a plan, implementing the plan, and assessing the plan's effectiveness. Each of the seven subscales contains nine items, with participants responding on a five-point Likert scale ranging from strongly disagree to agree strongly. The scoring and interpretation process of the SRQ is clear and straightforward. Total scores indicate self-regulatory capacity, with scores above 239 reflecting high capacity, scores between 214-238 indicating moderate capacity, and scores below 213 suggesting low capacity. The SRQ demonstrates excellent reliability, with a Cronbach's alpha of 0.81 and a high test-retest reliability index of $r = .94$ ($p < .0001$), confirming its effectiveness as a measurement tool for self-regulatory skills (Aubrey, Brown, & Miller, 1994) [31].

Knowledge of ICT

To explore EFL teachers' knowledge of Information and Communication Technology (ICT) and Mobile-Assisted Language Learning (MALL), the ICT Engagement Questionnaire developed by Zylka et al. (2015) [32] was employed. This scale, which comprises 36 items designed to assess various dimensions of ICT engagement, is particularly effective due to its use of a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total score can range from 36 to 180, with a reported reliability coefficient of 0.79, indicating acceptable internal consistency. The questionnaire is grounded in self-determination theory and evaluates four fundamental constructs: Interest in ICT, Perceived ICT competence, Perceived Autonomy in ICT usage, and ICT as a topic in social interaction. For instance, items such as "I enjoy learning about new technologies" assess Interest in ICT, while "I feel confident using different ICT tools" evaluate Perceived ICT competence. Understanding these constructs is essential for enhancing teachers' engagement with ICT, which is crucial for effective teaching in today's digital age. By measuring these dimensions, the questionnaire provides valuable insights into teachers' readiness to integrate technology into their pedagogical practices, ultimately fostering a more dynamic and interactive learning environment.

Structured Interview

To investigate EFL teachers' attitudes regarding their knowledge of ICT and MALL and its influence on their teaching practices, a semi-structured interview was conducted with 20 teachers who were randomly selected from a pool of 120 teachers who completed the questionnaires. Among the 20 EFL teachers, 13 held a Master's degree in English, 5 had a Bachelor's degree, and 2 were PhD candidates, all with teaching experience ranging from 5 to 15 years. The sample included 11 males and 9 females. The interview comprised four questions designed to explore teachers' perspectives on whether their knowledge of ICT and MALL could influence their methods of teaching English to learners, and these questions were formulated based on the objectives of the study. For qualitative data analysis, a thematic analysis approach was employed to identify and interpret patterns within the interview responses. The recorded interviews were transcribed verbatim, and the transcripts were systematically coded to categorize the data into meaningful themes. Data saturation was reached when no new themes or insights emerged from the interviews, indicating that the data collection had sufficiently captured the range of teachers' attitudes and experiences. This iterative process allowed for a deeper exploration of the participants' views, ultimately enriching the findings of the study. The questions of the interview were as follows:

Do you believe in the usefulness of MALL (mobile-assisted language learning) instruction for Iranian EFL students? Why?

If you are engaged in MALL instruction, what activities are practiced in your class?

What are the obstacles to implementing MALL instruction in Iran?

Do you have any other suggestions regarding the use the MALL instruction in the EFL teaching area?

Procedures

Over two months, the researcher collected data on 120 EFL teachers through various questionnaires (self-regulation, self-efficacy, and knowledge of ICT) at a private institute in Tehran, Iran. The questionnaires were delivered to the teachers via e-mail or WhatsApp, allowing respondents ample time to complete and return them. The researcher gathered and scored the returned questionnaires, utilizing SPSS version 21 (Statistical Package for the Social Sciences) to interpret the statistically gathered data. In the qualitative phase, a sample of 20 EFL teachers, selected for their diversity in gender and years of experience, participated in semi-structured interviews to explore whether their knowledge of ICT and Computer-Assisted Language Learning (CALL) influences their teaching practices. These interviews, conducted either in person or via video conferencing, lasted approximately 45-60 minutes and were audio-recorded with participants' consent. The reason for carrying out this interview was explained to all the participating teachers. It was explicitly stated that their personal information was not be shared with anyone, and only their anonymous responses were used in any possible reporting of this study. The interview data were transcribed verbatim and analyzed using thematic analysis, where the researcher generated initial codes, collated them into potential themes, and refined these themes to accurately capture the essence of the data. The findings were presented as descriptive extracts, providing rich insights into teachers' perceptions and experiences regarding the impact of ICT and CALL knowledge on their teaching approaches. This qualitative analysis complemented the quantitative findings, offering a comprehensive understanding of EFL teachers' self-regulation, self-efficacy, knowledge of ICT, and how these factors shape their teaching practices in the Iranian context.

Data Analysis

The Statistical Package for Social Science (SPSS) version 21 was the cornerstone of the data analysis, used to estimate questionnaire scores and establish links between variables. A variety of statistical analyses were employed, including descriptive statistics (mean, standard deviation, standard error of the mean) to summarize the data and inferential statistics to generalize the findings. Pearson product-moment correlation coefficient determined the correlation between variables, while skewness and kurtosis ratios verified data normality. Correlational analyses were conducted based on variable nature and study design, and multivariate regression analysis predicted EFL teachers' knowledge of ICT and MALL based on their self-efficacy and self-regulation. Qualitative data analysis, using thematic analysis, was conducted on the interviewees' verbatim-transcribed responses to gain deeper insights into teachers' perspectives. Open coding generated initial codes, which were categorized into broader themes representing underlying concepts related to the influence of ICT and MALL knowledge on teaching practices. The interview results were extracted and analyzed manually, and for the aim of reliability, 30% of the data was rechecked and reanalyzed independently by a second researcher (a PhD graduate of TEFL) who was informed about the purpose of the study by the researcher. The field of study of this expert was discourse analysis, and she was familiar with the data analysis phase. The second rater coded 30% of the data, taken randomly from the corpus, and finally, the inter-rater reliability was reported to be 0.95. To reduce researcher bias, intercoder agreement was established by involving a second researcher to independently code a subset of the data, with discrepancies discussed and resolved. This rigorous approach to qualitative data analysis complemented the quantitative findings, providing a comprehensive understanding of the factors influencing EFL teachers' instructional methods.

Results and findings

The results section presents a comprehensive analysis of the relationship between Iranian EFL teachers' engagement with MALL and ICT and their self-efficacy and self-regulation. SPSS version 21 was used for data analysis, employing descriptive and inferential statistics, Pearson product-moment correlation, and multivariate regression. Qualitative data from semi-structured interviews were transcribed verbatim and analyzed using thematic analysis, with open coding and intercoder agreement to ensure objectivity. This rigorous methodological approach provided a nuanced understanding of the factors influencing EFL teachers' instructional methods, highlighting the interplay between technology engagement and personal efficacy in language education.

Research Question One

The first research question focused on exploring whether there is any relationship between EFL teachers' knowledge of ICT and MALL and their self-efficacy.

The detailed descriptive statistics in Table 1 provide a comprehensive view of EFL teachers' self-efficacy, self-regulation, and knowledge of ICT and MALL, ensuring that the audience is well-informed.

Table 1: Descriptive Statistics of EFL Teachers' Knowledge of ICT and MALL, Self-efficacy, and Self-regulation

	N	Mean	Std. Deviation
Knowledge of ICT and MALL	120	164.35	3.45
Self-efficacy	120	83.14	4.56
Self-regulation	120	179.28	4.12

As Table 1 demonstrates, the teachers' mean in the knowledge of ICT is 164.3 with an SD of 3.4, and the mean of these teachers in self-efficacy is 83.1 with an SD of 4.5. The mean of these teachers in self-regulation is 179.2 with an SD of 4.12.

Before conducting the correlational analyses, it was crucial to check the related assumptions. To run a correlational analysis, it was necessary to ensure that certain assumptions were met; one of these was the linearity assumption. To check the linearity of the relation, the researcher visually inspected the data by creating a scatterplot, as shown in Figure 1. These findings are of significant importance and will contribute to our understanding of ICT and self-efficacy in teaching.

The inspection of Figure 2 shows that there was no kind of non-linear relationship between the scores on knowledge of ICT and MALL and self-efficacy, such as a U-shaped or curvilinear distribution. Moreover, the distribution was not funnel-shaped, i.e., wide at one end and narrow at the other; therefore, the assumption of homoscedasticity was met. The other assumption is that the data should be normally distributed. To this end, the researcher ran the test of normality in both the knowledge of ICT and the self-efficacy of EFL teachers. Table 2 shows the result of the test of normality related to the EFL teachers.

Table 2 illustrates the p-value in the EFL teachers' knowledge of ICT and MALL, which is higher than the significance level (.05), indicating a typical data distribution. Another significant tool in our study was the self-efficacy scale, the results of which are presented in Table 3, providing further insights into our research.

As indicated in Table 3, since the p value is higher than the significance level (.05), it can be concluded that the data is normally distributed. To assess Research Question 1, a Pearson correlation analysis was conducted. Table 4 indicates the results of the correlation analysis between EFL teachers' knowledge of ICT and MALL and their self-efficacy.

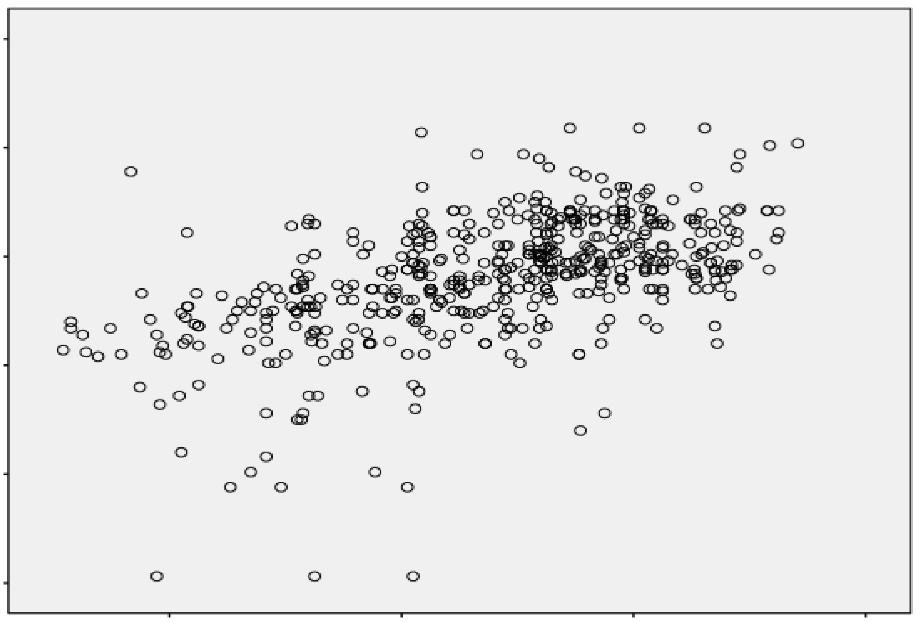

Fig. 2: Scatterplot of EFL teachers' knowledge of ICT and MALL and self-efficacy

Table 2: Tests of Normality for EFL Teachers' Knowledge of ICT and MALL

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
EFL Teachers' Knowledge of ICT and MALL	.127	120	.071	.953	120	.058

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 3: Tests of Normality for EFL Teachers' Self-efficacy

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Self-efficacy	.062	120	.200*	.982	120	.531

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 4: Correlation between EFL Teachers' Knowledge of ICT and MALL and Self-efficacy

		Self-efficacy	Knowledge of ICT and MALL
Knowledge of ICT and MALL	Pearson Correlation	1	.732
	Sig. (2-tailed)		.000
	N	120	120
Self-efficacy	Pearson Correlation	.732	1
	Sig. (2-tailed)	.000	
	N	120	120

The results of the Pearson correlation analysis showed that the EFL teachers' knowledge of ICT and MALL correlated positively and highly with their self-efficacy, $r = .73$, $p<.05$. This finding has inspiring practical implications, suggesting that enhancing teachers' knowledge of ICT and MALL can significantly boost their self-efficacy. The R-squared value equals 0.73, indicating that the teachers' knowledge of ICT and MALL can predict their self-efficacy by up to 49 percent. Therefore, the first null hypothesis, which claimed "There is no significant relationship between EFL teachers' knowledge of ICT and MALL and their self-efficacy," was rejected, opening up new possibilities for improving EFL teaching practices.

Research Question Two

The second research question focused on exploring whether there is any relationship between EFL teachers' knowledge of ICT and MALL and their self-regulation. A series of statistics was run. Table 5 shows the descriptive statistics regarding EFL teachers' knowledge of ICT and MALL and their self-regulation.

Table 5: Descriptive Statistics of EFL Teachers' Knowledge of ICT and MALL, and Self-regulation

	N	Mean	Std. Deviation
Knowledge of ICT and MALL	120	164.35	3.45
Self-regulation	120	179.28	4.12

Table 5 shows that the teachers' mean in ICT knowledge is 164.3 with an SD of 3.4. The mean of these teachers in self-regulation is 179.2, with an SD of 4.1. As previously mentioned, we ensured that the related assumptions were checked before running the correlational analyses. One of these assumptions is the linearity assumption, which we meticulously verified. The first step was to examine the linearity of the relation in knowledge of ICT, MALL, and self-regulation (See Figure 2).

Figure 3 examination confirms the absence of a non-linear relationship between ICT and MALL knowledge scores and self-regulation, thereby validating the homoscedasticity assumption. The normality test was then conducted on ICT knowledge and EFL teachers' self-regulation. Table 2 presents the normality test results for EFL teachers' understanding of ICT and MALL, confirming the normal distribution. The same test was performed for self-regulation, with Table 6 displaying the results.

As indicated in Table 6, since the p-value is higher than the significance level (.05), it can be concluded that the data is usually distributed in the test of self-regulation, so that a Pearson correlation can be conducted. Table 7 indicates the results of the correlation analysis between EFL teachers' knowledge of ICT and MALL and their self-regulation.

The results of the Pearson correlation analysis showed that the EFL teachers' knowledge of ICT and MALL correlated positively and highly with their self-regulation, $r = .79$, $p<.05$. It can be concluded that there is a positive relationship between the teachers' knowledge of ICT and MALL and their self-regulation. Based on the results, the R-squared value equals 0.79. This means that the teachers' knowledge of ICT and MALL can predict their self-regulation by up to 62 percent. Therefore, the second null hypothesis, which claimed "There is no significant relationship between EFL teachers' knowledge of ICT and MALL and their self-regulation," was rejected.

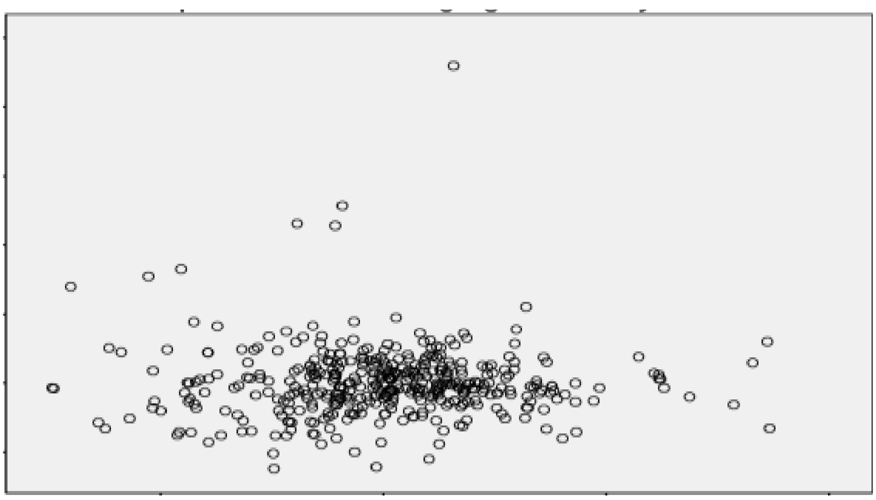

Fig. 3: Scatterplot of knowledge of ICT and MALL, and self-regulation

Table 6: Tests of Normality for EFL Teachers' Self-regulation

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Self-regulation	.073	120	.200*	.874	120	.642

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 7: Correlation between EFL Teachers' Knowledge of ICT and MALL and Self-regulation

		Self-regulation	Knowledge of ICT and MALL
Knowledge of ICT and MALL	Pearson Correlation	1	.791
	Sig. (2-tailed)		.000
	N	120	120
Self-regulation	Pearson Correlation	.791	1
	Sig. (2-tailed)	.000	
	N	120	120

Research Question Three

Finally, the last research question aimed to explore the perceptions of EFL teachers about knowledge of ICT and MALL and their improvement in teaching English. To investigate EFL teachers' attitudes regarding knowledge of ICT and MALL by teachers and its influence on teaching English to learners, a semi-structured interview was employed with 20 teachers using a set of questions. The interview's questions aimed to probe teachers' attitudes on why MALL instruction is helpful for Iranian EFL students. Almost all of the teachers (19 out of 20 teachers =90%) believed that MALL is useful for L2 students and mentioned different reasons for its effectiveness. The first reason expressed by most of the teachers was the increased variety of education options. The answers to interview questions were elaborated on in the following extracts:

The investigation into the effectiveness of MALL for L2 students highlights several advantages, including increased educational options and flexibility, as students can engage in courses without the constraints of transportation and rigid schedules. MALL allows students to pursue the same range of degrees as traditional education while studying at their convenience from any location with internet access. Teachers noted that MALL enhances interaction through innovative teaching techniques, such as interactive videos and whiteboards, which foster student engagement and allow for review of recorded sessions. However, some teachers expressed concerns about low interaction levels in MALL environments, citing technical issues and a lack of engagement as potential drawbacks. Various skills, including reading and listening, are practiced through MALL, with teachers utilizing games, photos, and podcasts to cater to different learning styles. Despite its benefits, low internet access emerged as a significant obstacle to implementing MALL in Iran, attributed to high filtering and censorship. Teachers suggested that a blended approach, integrating MALL with traditional classrooms, could mitigate these challenges by enhancing interaction and providing alternative access to resources, thereby creating a more inclusive and effective learning environment. Overall, the findings underscore the potential of MALL in EFL instruction while also addressing the need for improved infrastructure and teaching strategies to maximize its effectiveness.

Discussion

The objectives of the current study, which hold significant implications for the field of language teaching and technology, were as follows:

a. To investigate the relationship between Iranian EFL teachers' self-efficacy, self-regulation, and their knowledge of ICT and MALL.

b. To examine EFL teachers' attitudes about using MALL-based instruction in L2 classes.

The data analysis, conducted with meticulous attention to detail and the findings revealed the existence of relationships (with different strengths) among the variables under the study. To answer research questions, the researcher employed Pearson correlation and multiple regression. The findings revealed a positive relationship between Iranian EFL teachers' knowledge of ICT and MALL and their self-efficacy as well as their self-regulation.

One justification for the relationship between the teachers' knowledge of ICT and MALL and their self-regulation and self-efficacy was the fact that the new and different instructional setting and the fun nature of MALL-based classes made teachers and learners more motivated and active in teaching English. This increase in motivation leads to an increase in self-regulation, self-efficacy, and other related personality traits [33]. This is consistent with other research that found that environments with technology-enhanced learning are superior to those without these features in promoting self-regulated learning [34].

The instructors' experience with computers, information technology, and the internet in the Iranian EFL context may justify such significant findings. As a result, teachers may have relied too heavily on MALL-based instruction, which can boost teachers' self-efficacy. Furthermore, the over-reliance on online courses helps teachers to regulate themselves, and the development and use of self-regulated learning behaviors are context-dependent [35]. Indeed, when teachers scaffold students' learning and educate them to self-regulate before a task, students are more likely to ask for help and co-regulate with the teacher [36]. The potential learning benefits, including those from blended learning instruction in learning English, underscore the value of efforts to build self-efficacy and self-regulation [37].

Online classrooms facilitate and require the teachers' self-regulation and self-efficacy [37]. The self-regulation component is essential for web-based instruction since teachers become more accountable for their instruction, more intrinsically motivated, and more challenging due to their high self-efficacy and suitable self-regulated techniques [38]. Moreover, teachers can actively control their motivation, behavior, or cognition, achieving teaching objectives and doing better [39]. Self-regulated learning is not a fixed trait, and teachers can improve their motivation and learning strategies when effective teaching environments are provided [40]. Online learning highly demands teachers' self-efficacy and self-regulatory skills, making it particularly difficult for those with lower levels of these skills [41].

One reason for the results can be the widespread role of online teaching and e-learning tools that have been developed worldwide, and Iran was no exception. The teachers were already familiar with ICT and technology, and this awareness enabled the teachers to reach the standards of modern and up-to-date teachers. To the researcher's knowledge, there is no study to report on the e-learning literacy of EFL teachers. However, some researchers have examined the relationship between teacher job efficacy and computer literacy. Alabi and Yisa (2013) [42] looked into how computer literacy affected teachers' ability to perform their jobs effectively, and they discovered a strong link between the two. This is in line with the findings of Akinnubi et al. (2012) [43], who found a strong relationship between online literacy and teachers' ability to do their jobs effectively.

As the results of the data analysis revealed, teachers knew MALL, and their self-regulation and self-efficacy increased due to an increase in ICT and MALL knowledge. Another reason for the high e-learning literacy of EFL teachers can be the situations that COVID-19 exposed the teachers. They were obliged to increase e-learning literacy as soon as possible. The COVID-19 epidemic has altered our perception of the universe in the twenty-first century. Every department and field is impacted. New fashions and trends are developing to thrive in this environment. Even while teachers have grown accustomed to the old teaching methods in face-to-face lectures, they are reluctant to accept any change because it would require some urgent innovations and improvements. Although old methods have value, in this crisis, there is no other option but to adapt to the changing environment and accept change, which will raise levels of self-efficacy and self-regulation.

The results of interviews with the teachers showed that teachers' knowledge in ICT and MALL was high enough in a context like Iran, where low internet access was one of the significant drawbacks in virtual classrooms that caused lots of problems, such as wasting time and lowering the interaction level. However, due to the teachers' ICT knowledge, they mentioned some solutions and suggestions, such as the use of flipped classes and the use of simultaneous online and traditional environments. The findings are consistent with Lee, Kang, Kim, Hong, and Sonya's study from 2023 [44], which attempted to evaluate how remote laboratory courses would be affected by "social separation" caused by the COVID-19 pandemic [44]. According to the authors, there are several obstacles to creating virtual schools, such as a lack of internet connectivity nationwide and few resources available to a broad community during such outbreaks. These results highlight the need to promote human interaction, essential for student learning and practice. One way to achieve this is through the use of 'interactive technology', which includes tools and platforms that facilitate real-time communication, collaboration, and feedback, thereby enhancing the learning experience in online social work classes [45]. To build and implement the systems for virtual classrooms, one needs appropriate training in this technology and thorough program preparation, which are requirements that need to be included in teaching training courses in Iran.

The current study indicated that the interplay between Iranian EFL teachers' self-efficacy, self-regulation, and their knowledge of ICT and MALL is crucial for fostering a more effective language teaching environment. The positive correlations identified suggest that enhancing teachers' familiarity with technology can lead to improved self-efficacy and self-regulation, which are essential for the successful implementation of MALL-based instruction. The findings align with existing literature that emphasizes the importance of technology in education. As noted, environments enriched with technological tools not only engage learners but also empower teachers to adopt innovative pedagogical strategies. This is particularly relevant in the Iranian EFL context, where traditional teaching methods have often dominated. The shift towards MALL and ICT integration offers a promising avenue for revitalizing language instruction and promoting a more dynamic learning atmosphere. Furthermore, the results underscore the necessity for professional development programs aimed at improving teachers' ICT competencies. Such initiatives can help bridge the gap between traditional teaching practices and modern educational demands, ultimately enhancing both teacher and student outcomes. By equipping teachers with the necessary skills and knowledge to navigate digital tools, educational institutions can cultivate a workforce that is both confident and capable in implementing MALL-based instruction. The study's findings also highlight the significance of self-regulation as a critical component of effective teaching practices in online environments. Teachers who can manage their own learning and adapt their instructional strategies are more likely to foster an environment conducive to student engagement and success. This suggests that teacher training programs should not only focus on technological skills but also emphasize the development of self-regulatory strategies to enhance teaching effectiveness. In conclusion, the current study contributes to the growing body of research on MALL and ICT in language education by providing insights into the relationships between self-efficacy, self-regulation, and technological knowledge among Iranian EFL teachers. It calls for a concerted effort to enhance teachers' technological competencies and self-regulatory skills through targeted professional development initiatives. By doing so, educators can better meet the challenges of modern language teaching and ultimately improve student learning outcomes in an increasingly digital world. Future research could further explore the long-term effects of these interventions on both teacher performance and student achievement, as well as investigate the specific challenges faced by teachers in integrating MALL and ICT into their classrooms.

To sum up, Online teaching approaches assist in facilitating learning-teaching processes, but it is necessary to assess the benefits and drawbacks of technology and realize its full potential. Disasters and pandemics like COVID-19 make the situation very chaotic and tense; therefore, it is necessary to thoroughly and diligently analyze technology. This underscores the seriousness and gravity of the problem and the need for a comprehensive understanding of technology during such crises [46]. The use of convenience sampling and a focus on private language centers in Tehran may restrict the generalizability of the study's results. Future research should aim for a more diverse sample across different locations and educational settings to improve the applicability of the findings.

Conclusions

The results of this study indicate a positive correlation between teachers' knowledge of ICT and MALL and their self-efficacy and self-regulation. Quantitative analysis revealed that teachers proficient in digital technologies and mobile applications for language learning demonstrated higher confidence and effective self-regulatory strategies. Qualitative insights from structured interviews confirmed teachers' strong understanding of ICT and MALL, highlighting how technology engagement enhanced lesson planning, classroom management, and teaching effectiveness. This combination of quantitative and qualitative data underscores the significant relationship between teachers' technological competencies, self-beliefs, and self-regulatory practices.

Overall, learning almost anything online is a fresh and intriguing process. It has positively impacted the lives of both teachers and kids [47]. The quality of education has increased due to the expanding use of technology in the classroom, especially in the COVID-19 era. Although MALL-based training will have a more significant impact in the future, the study found that it cannot replace conventional face-to-face classroom instruction. Making the whole transition to online learning might take time and effort. We must recognize the benefits of virtual learning environments in light of what EFL teachers have stated. As a result, it's essential to understand the obstacles to accepting online learning and take the required steps to remove them.

The findings of this present study have significant implications for EFL teachers who want to apply an effective method in teaching English skills and sub-skills in the conditions we experienced during the Coronavirus pandemic. At times like this, MALL-based classrooms can address the unavailability of traditional classrooms. Teachers can use MALL-based education in their classes to supplement their courses. Online classes can also be used in disabled students' classrooms. One of the standard features of students with disabilities is their passiveness. With the assistance of MALL-based instruction, teachers, especially those with high ICT knowledge, could encourage students' active participation in the classroom since those teachers are successful in both cognitive and affective factors. A teacher who knows how to work with computers, search for data, find resources easily, or present them with new technology will feel more confident and even broaden their goals in teaching. The findings could be helpful for syllabus designers to make homogeneous classification plans and supplement their courses with different tasks and reliable and accurate assessment tools to decrease cheating and increase the validity of virtual classrooms. In addition, L2 task designers need to consider the cognitive demands of the tasks in terms of selection and sequencing when preparing online platforms.

Virtual classrooms would be one of the best choices not only in English classrooms but also in other majors and fields, and teachers' high knowledge of ICT resulted in students' high performance in various courses. It is recommended that this study be replicated with an equal number of male and female participants. Hence, gender may function as an influencing factor. Also, in other ESL and EFL settings, the same research can be done to determine how learners' socio-affective qualities, such as self-control and motivation, relate to the factors employed in the current study. This underlines the need for further research in the field and the potential impact it can have on language education.

Authors' Contribution

The first two authors made significant contributions to the content of the article, while the third author played an important role in writing the literature review and organizing the article.

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Conflicts of Interest

There was no conflict of interest among the authors.

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ORIGINAL RESEARCH PAPER

The effectiveness of blended learning with electronic concept maps on social studies learning

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ABSTRACT

Background and Objectives: The integration of in-person teaching with digital education has given rise to a new approach to learning and teaching known as blended learning. When implemented effectively, blended learning can enhance the academic success and overall learning experience of students. Additionally, the use of modern theories of learning, such as constructivism, and learning strategies like concept mapping, can transform students from passive receivers of information to active participants in their academic journey. Concept maps created using computer-based tools have been integrated into many learning strategies, including blended learning. A recent study was conducted to explore the effectiveness of concept map-based blended learning on the social studies learning of male sixth-grade students.

Materials and Methods: The study followed a semi-experimental research method with a pre-test-post-test design and a control group. The participants were all male sixth-grade students from Birjand in 2023. The sample size consisted of 60 male students chosen through available sampling. The pre-test-post-test of the social studies researcher was used to collect data. The test questions' content validity was assessed using a two-dimensional table of objective-content, and the face validity was confirmed by experts and three sixth-grade colleagues. The test's reliability coefficient was calculated through Cronbach's alpha coefficient, which was 0.81. The test consisted of two parts, with the first part collecting demographic information and providing instructions for completing the questions. In addition to descriptive statistics, the analysis of covariance statistical test was used to analyze the data.

Findings: Based on the results of the study, it can be concluded that there is a notable difference in the average scores of the learning variables of the experimental and control groups. The application of combined training based on a conceptual map has proven to explain 19.2% of the variance of the learning post-test scores, which is a significant result ($F_{(57,1)}$ =60.13, $p<0.005$, partial η^2=2.19 %).

Conclusions: According to research, blended learning based on concept maps has been found to be effective in enhancing students' social studies learning. The ongoing COVID-19 pandemic has forced many educational institutions to adopt virtual education as the only means of ensuring the safety of students and staff. However, with the end of the pandemic, there are concerns about the weaknesses in various educational fields that have come to light during this period. Therefore, the use of blended learning centered on the use of electronic concept maps is an effective approach to eliminate the weaknesses caused by virtual education during the pandemic and an effective measure to compensate and stabilize their learning in the post-coronavirus era. This approach will make a deeper connection between the main concepts of the new lesson and the students' previous learning, and the main role in this process will be the responsibility of the student. Among the limitations of the current research, we can mention experimental interventions by the researcher, which can influence the bias of the results. Not having a follow-up phase was another limitation of the above study. Therefore, it is suggested that other researchers, by removing the mentioned methodological limitations and also applying other variables affecting learning, should try to conduct new research with different societies and sample sizes, in other subjects and levels of study, and with different genders. This increases the accuracy of the results and increases the generalizability of the

results. Based on the results obtained from the present study, it is possible to hold workshops and training courses in order to enable colleagues to use electronic concept maps and use them in teaching. In addition to the above, electronic concept maps can be used in the teaching-learning process in the curriculum of the second elementary school. An effective method is to use a combination of work and technology courses, social studies and art. In addition to strengthening learning, this can also be effective in developing students' aesthetic sense. Finally, using technological literacy in the design of concept maps and encouraging students to use it during class presentations can be considered as other practical suggestions that strengthen the motivation of students to progress.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
46	1	5

مقاله پژوهشی

اثربخشی یادگیری ترکیبی مبتنی بر نقشه مفهومی الکترونیکی بر یادگیری مطالعات اجتماعی

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چکیده

پیشینه و اهداف: ترکیب آموزش حضوری با آموزش الکترونیکی، منجر به ایجاد شیوه‌ای جدید در آموزش و یادگیری به نام یادگیری ترکیبی گردیده است که در صورت استفاده صحیح به بهبود یادگیری و موفقیت تحصیلی دانش‌آموزان منجر می‌شود. از سوی دیگر، تاکید بر نظریات جدید یادگیری چون ساختن‌گرایی و به کارگیری آن در راهبردهایی چون نقشه های مفهومی یادگیرنده را از منفعل بودن و دریافت کننده صرف اطلاعات دور کرده و درگیری تحصیلی او را به ارمغان می آورد. نقشه های مفهومی رایلنه محور در استراتژهای یادگیری متعددی از جمله یادگیری ترکیبی به خدمت گرفته شده اند. پژوهش حاضر باهدف بررسی اثربخشی آموزش ترکیبی مبتنی بر نقشه مفهومی بر یادگیری مطالعات اجتماعی دانش‌آموزان پسر پایه ششم انجام شد.

روش‌ها: روش پژوهش نیمه آزمایشی با طرح پیش‌آزمون- پس‌آزمون همراه با گروه کنترل بود. جامعه آماری پژوهش تمامی دانش‌آموزان پسر پایه ششم ابتدایی شهرستان بیرجند در سال تحصیلی ۰۲-۰۱ بودند. نمونه آماری پژوهش ۶۰ نفر از دانش‌آموزان پسر پایه ششم بودند که با شیوه نمونه‌گیری در دسترس انتخاب شدند. برای گردآوری داده‌ها از پیش‌آزمون - پس‌آزمون محقق ساخته مطالعات اجتماعی استفاده گردید. با استفاده از جدول دوبعدی هدف-محتوا روایی محتوایی سوالات آزمون مورد بررسی قرار گرفت. همچنین، متخصصان و ۳ تن از همکاران پایه ششم روایی صوری آزمون را تایید کردند. همچنین، ضریب پایایی سؤالات آزمون نیز با استفاده از ضریب آلفای کرونباخ محاسبه شد که میزان ۰/۸۱ به دست آمد. این آزمون دارای دو بخش بود. در بخش نخست، ضمن دریافت اطلاعات جمعیت شناختی مشارکت کنندگان، دستورالعمل تکمیل سوالات نیز گنجانده شده بود و بخش دوم نیز حاوی ۲۰ سوال چهارگزینه ای بود که از ۸ درس آخر کتاب مطالعات اجتماعی تهیه و طراحی شده بود. جهت تجزیه‌وتحلیل داده‌ها، علاوه بر آمار توصیفی از آزمون آماری تحلیل کوواریانس استفاده شد.

یافته‌ها: نتایج نشان داد که بین میانگین نمرات متغیر یادگیری مطالعات گروه‌های آزمایش و کنترل تفاوت معناداری وجود دارد. با در نظر گرفتن مجذور لتا می‌توان گفت کاربرد آموزش ترکیبی مبتنی بر نقشه مفهومی، ۱۹/۲ درصد واریانس نمرات پس‌آزمون یادگیری را تبیین می‌کند($F_{(57,1)}$=13/60, p<0/005 partial η^2=19/2%) .

نتیجه‌گیری: یافته‌های پژوهش نشـــان می‌دهد که آموزش ترکیبی مبتنی بر نقشـــه‌های مفهومی بر یادگیری مطالعات اجتماعی دانش‌آموزان موثر بوده اســـت. همانطور که مطالعات نشـــان می‌دهند در طی دوران همه‌گیری کرونا، آموزش مجازی تنها راه ممکن برای حفظ سلامتی یادگیرندگان و جلوگیری از بسته شدن طولانی مدت اماکن آموزشی قلمداد شد و اکنون پس از پایان دوران همه‌گیری کرونا، ضعف های جدی در زمینه های متعدد تحصیلی و تربیتی مشاهده می گردد. بنابراین، بهره¬گیری از یادگیری ترکیبی با محوریت اســـتفاده از نقشـــه های مفهومی الکترونیکی، رویکردی اثربخش در رفع ضـــعف‌های ناشـــی از آموزش مجازی در دوران همه گیری و اقدامی مؤثر در جهت جبران و تثبیت یادگیری آنان در پسا کرونا است. این رویکرد سبب خواهد شد تا بین مفاهیم اصلی درس جدید و آموخته های قبلی دانش آموزان پیوند عمیق تر برقرار گردد و نقش اصـــلی در این فرآیند برعهده دانش آموز باشـــد. از محدودیت های پژوهش حاضـر، می توان به مداخلات آزمایشـی توسـط پژوهشـگر اشـاره کرد که می تواند در سـوگیری نتایج تاثیرگذار باشـد. نداشـتن مرحله پیگیری از دیگر محدودیت های مطالعه فوق بود. لذا، پیشـنهاد می گردد سـایر پژوهشـگران با رفع محدودیت های روش شـــناختی ذکر شـــده و همچنین اعمال ســـایر متغیرهای موثر بر یادگیری نســـبت به انجام پژوهش های جدید با جوامع و حجم نمونه متفاوت، در دروس و مقاطع تحصـیلی دیگر و با جنسـیت‌های متفاوت مبادرت ورزند. این امر دقت نتایج را بالا برده و بر قدرت تعمیم دهی نتایج می افزاید. بر اســاس نتایج به دســت آمده از مطالعه حاضــر می‌توان نسبت به برگزاری کارگاه و دوره های آموزشی در جهت توانمندی همکاران در به کارگیری نقشه های مفهومی الکترونیکی و بهره گیری از آن در تدریس اقدام کرد. افزون بر موارد فوق، می توان در برنامه درسی و آموزشی دوره دوم ابتدایی از نقشـه های مفهومی الکترونیکی در جای جای فرآیند یاددهی-یادگیری اسـتفاده کرد. یک روش موثر، اسـتفاده از تلفیق دروس کار و فناوری، مطالعات اجتماعی و هنر اســـت. این امر می تولند علاوه بر تقویت یادگیری در پرورش حس زیبایی شناختی دانش آموزان نیز موثر باشد. در نهایت، بهره گیری از سواد فناورانه در طراحی نقشه های مفهومی و تشویق دانش آموزان به استفاده از آن به هنگام ارائه های کلاسی را می توان از دیگر پیشـنهادهای کاربردی که انگیزه پیشرفت را در دانش آموزان تقویت می کند، دانست.

Introduction

In today's world, the rapid and sudden changes that originate from advances in science and technology have affected all aspects of human life, including education [1,2]. Education is considered the basis of all development of the country, or is somehow tied to it [3]. Therefore, educational systems must adjust themselves step by step with these developments and try to improve and upgrade themselves [4]. This improvement in educational systems and the use of new approaches in education is a necessity. Today, there is a lot of emphasis placed on using technology to solve existing problems, reduce the gap between the current and desired conditions, and also improve the learning and academic success of students. It is undeniable that the role of information and communication technology in improving and creating a revolution in education and learning has been significant [5].

Before the coronavirus pandemic, there were various methods of education. Most countries relied on face-to-face and traditional training, while each educational system used different mobile learning approaches, blended learning, reverse learning, and more, based on their technical infrastructure and educational perspectives. However, the sudden outbreak of COVID-19 in 2019 changed everything [6,7]. Following the World Health Organization's announcement, educational centers from elementary schools to universities were shut down [8]. Statistics reveal that almost half of the world's student population (nearly 900 million people) was impacted by this phenomenon at the start. [9]. Furthermore, it was estimated that over a population of one and a half billion people followed virtual education [10]. Therefore, with social distance measures in place and schools and educational facilities closed, changing the educational system's traditional approach to virtual education became a fundamental and significant challenge [11].

The shift from traditional face-to-face education to virtual learning was necessitated by a lack of infrastructure and planning, communication issues, and a lack of technical expertise among teachers [12,13]. Despite these challenges, virtual education was seen as the only viable solution to continue the education process during the pandemic. In other words, virtual education was a response to the COVID-19 epidemic, and the world was pregnant with conditions where, for the first time, all education and learning were done in a virtual way [12]. Over time, technical and communication problems were addressed and reduced. However, as the world returns to in-person learning, the challenges of virtual education are becoming more apparent. While some technical and infrastructure issues may be unique to the virtual learning era, any weaknesses in these areas can have long-term negative effects on student education [14].

It's important to recognize that there are many physical, social, and cultural challenges that can impact students in the post-corona era. Some of these challenges include obesity, diabetes, bad sitting habits, poor vision, and extreme fatigue [15], mental health problems like depression and isolation, aggression, and even cell phone addiction [16]. Students may also struggle with drowning in the Internet and virtual world, dropping out of school, and facing educational challenges, such as weakness in basic courses due to the lack of real and meaningful interaction in this type of education [17]. It's also worth noting that some students may lack technological literacy, while others may struggle with attention, concentration, and digital distraction[18]. Also, a lack of attention to individual differences [12,14], ignoring learning styles, lack of efficiency in practical and laboratory courses are some of the other problems [7]. There may also be ethical issues such as cheating, abuse of virtual education in the classroom and monthly evaluations, problems with parental involvement, and poor upbringing. All of these factors can contribute to a fundamental weakness in students during this time. It's important to recognize and address these challenges in order to support students and help them succeed [19–21].

Considering the experiences gained during the virtual education era brought on by the coronavirus pandemic, it seems that incorporating new educational approaches could help improve the teaching process. This includes preparing necessary infrastructures, possessing technical knowledge, and reopening schools. These measures can help eliminate educational deficiencies and weaknesses caused by the pandemic, and also stabilize learning in the post-coronavirus era. One such approach is the use of blended learning methods, which emphasizes conceptual maps [22]. Human progress in educational technologies has shown that this method can improve the quality and richness of learning, as well as increase student participation in the teaching and learning process [23].

Upon doing some research on blended learning, it was found that there is much debate on a single definition of it. As a result, different definitions have been presented [24]; but two definitions seem to be more commonly used. The first one defines blended learning as ‘the integration of face-to-face training and computer training [25]. The second definition refers to it as ‘the thoughtful combination of face-to-face classroom learning experiences with online learning experiences’ [26]. What the two definitions have in common is that the key elements of blended learning are face-to-face and e-learning [27,28].

Blended learning refers to a course that combines online and face-to-face methods of content delivery. The main emphasis is on online presentations and discussions rather than face-to-face practices. The ratio of online to face-to-face can range from 30 to 79 percent [1]. Blended learning involves a combination of learning methods, content, and experiences. This can include integrating electronic learning with traditional learning, combining online learning with face-to-face learning, or using a blended pedagogy (Figure 1) [22]. It's worth noting that when discussing blended learning research, it's not common to focus solely on teaching or learning, as they are two sides of the same coin [27].

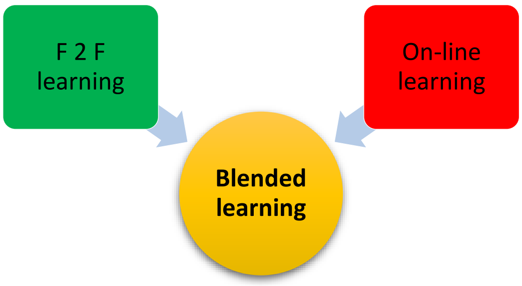

Fig. 1: the definition of blended learning

As the world of education shifts towards new perspectives and approaches to learning, such as the constructivist approach, the methods of teaching and presenting content have also undergone tremendous changes [29]. This approach emphasizes the active and dynamic presence of the student as the main focus of teaching and learning. By combining this approach with the latest technologies, we can effectively organize, repeat, and review the contents. One such technique is the use of map tools, which come in various software for drawing and presenting content. These map tools can visually display information, concepts, and connections between ideas [30], and have been called by various names, such as mental maps, concept maps, and proof maps [31]. By incorporating these tools in teaching, we can enhance students' learning experience and overcome the challenges posed by virtual education during the time of COVID-19. Both teachers and students can benefit from the use of these map tools, which can stabilize learning and improve its efficacy [5].

Concept maps are a powerful tool for organizing information and improving learning outcomes. They are a visual representation of the relationships between concepts, arranged in a hierarchical format that facilitates understanding and retention of knowledge [30,32]. The use of concept maps is supported by the fact that they closely resemble the way our minds naturally function [33], making them an effective strategy for learning; it is defined as an active learning method to record ideas on a horizontal level [34]. , making them an effective strategy for learning. Concept maps can be created using either pencil and paper or electronic formats, with the latter being increasingly popular due to their flexibility and multimedia capabilities. By incorporating colors, audio, video, and photos, electronic concept maps offer a dynamic and engaging way to connect knowledge in seamless scenarios [5]. This feature is particularly effective for enhancing learning, memorization [35], motivation, and attention to content [35,36]. Whether created manually or electronically, concept maps are a valuable tool for anyone seeking to improve their understanding and recall of complex information [5].

In this way, learning becomes effective through the use of images, colors, and connections between concepts. This approach aims to stimulate the mind to seek meaningful learning [33]. According to this theory, comprehensive information in a field of knowledge is displayed in a systematic and hierarchical manner, creating the cognitive structure of the individual [5,29]. Teachers can benefit from using mind maps in all stages of teaching, from curriculum content design to student learning evaluation. At the beginning of teaching, mental maps can act as pre-organizers, while at the end, the teaching-learning process can create a continuum of content in the student's mind. As a result, the student considers the new material as part of the more general material already learned [37]. This approach integrates and harmonizes the learner's mind, leading to meaningful learning and the development of new ideas [33].

It's interesting how the current research looks at various variables, including social studies learning, which is considered to be one of the fundamental courses in elementary school. Social studies cover topics such as history, geography, and social (civil) concepts, which help students learn about values, social environments, and human interactions. The ultimate goal is to train students to become good citizens. It's crucial to recognize the significance of this academic course, particularly social studies, in nurturing talents, developing learners' personalities, and shaping their professional and academic lives. That's why it's important to explore new teaching and learning methods [38].

Studies have shown that teaching with the help of concept maps using a blended approach has several benefits. Although several studies have mentioned the improvement of learning as one of the most fundamental advantages of using concept maps in the teaching-learning process, several studies also show the useful results of these graphic structures in evaluation, linking the content to the learner's cognitive construction [39] and improving new experiences [37]. With the change of teaching and learning approaches from being teacher-centered to student-centered approaches and theories, the use of mind maps as an active approach to use students' lateral thinking has been emphasized. Therefore, mind maps are a popular tool for structuring and visualizing information and helping students generate new and better ideas [34,37]. Using this technique can improve the problem-solving process in students while improving thinking skills [33]. Improving the level of motivation [40], increasing attention, and self-confidence are also other benefits of this type of learning [22].

According to the research literature, blended learning and concept maps have many benefits for students, and with the challenges posed by virtual education during the COVID-19 pandemic, there is a need for effective solutions. The use of electronic concept maps in blended learning environments is a promising approach to address these challenges and improve student learning outcomes. Interestingly, despite the potential benefits of this approach, there have been no studies conducted in this field to date, making this research both innovative and important. The main research question is whether blended learning based on concept maps is effective in enhancing the social studies learning of sixth-grade male students in the post-corona era.

Review of the Related Literature

The review of the studies conducted in this field shows the effectiveness of this educational method in the teaching-learning process and its results. According to a study conducted by Slovi and Chandramohan, using mind maps can be effective in helping students remember concepts. The study found that there is a correlation between academic progress and students' attitudes towards using concept maps. Furthermore, the results showed a positive and significant impact on learning when using this technique [40]. Also, according to research conducted by Nouri Shirazi et al., which focused on the effect of Azobel's theory concept maps on the prevention of academic failure and learning deterioration in the Corona era, it was found that concept maps have a positive impact on reducing academic failure among third-grade primary school students. The study, which involved two experimental groups with 30 students in each group, demonstrated that concept maps helped to improve students' reasoning in academic achievement tests and also promoted their self-regulated learning [17].

Also, it's interesting to note that Bardel and Mahmoudabadi conducted a study on the effectiveness of two teaching methods in teaching sixth-grade experimental sciences. Their research found that the teaching method based on conceptual maps had a significant impact on the academic progress of male students in sixth grade. It was able to achieve the expected goals in experimental science classrooms in a favorable manner compared to traditional teaching methods [41]. In addition, Prestia et al.'s research found that concept maps designed with Scratch software can improve meaningful learning. Additionally, the study showed that these concept maps had a positive impact on students' understanding of knowledge, as evidenced by the results of the paired t-test on pre-test and post-test scores [37]. Pandey and Tyagi say concept maps can be a valuable resource for education. According to their research, concept maps have been shown to enhance the overall learning experience by providing a graphical representation of information that can help students better organize and integrate what they're learning. It's great to see that there are innovative teaching tools out there that can make learning more engaging and meaningful for students [42].

Romero and his colleagues highlighted the importance of learners understanding the principles behind creating concept maps in their study titled "Meaningful learning using concept maps as a learning strategy". In fact, the research found that the learners who received training for designing concept maps as a learning strategy were highly satisfied with the training and found it to be useful in learning science lessons [43]. The study conducted by Yarmohammadi Vasil et al. aimed to compare the effectiveness of teaching with individual and group concept maps on the motivation and academic progress of learners in the social studies course. Based on the results, it was found that teaching with the help of concept maps was more effective in teaching the lesson, and group concept maps were found to be more effective than individual concept maps. This study highlights the importance of incorporating visual aids such as concept maps in teaching to enhance learning outcomes [44].

Method

Participants

The statistical population consisted of all male sixth-grade students in 2023. The statistical sample included 60 male sixth-grade students from Birjand city, who were selected through available sampling in the form of two classes with 30 students in each one. Class "A" was the experimental group, which was taught using the combined method (f 2 f + E-learning), while class "B" was taught in the usual way(f 2 f). The participants were selected based on similar demographic characteristics, such as age, gender, and educational status. All participants were 12 years old.

Instruments

To collect research data, the teacher of the social studies course used educational progress tests in the form of a pre-test-post-test of learning. The test questions were based on the last 8 lessons of the sixth-grade social studies textbook. The validity of the test was ensured through face validity, which involved examining the test items for their appearance, simplicity, clarity, question proportionality, and more. Additionally, the two-dimensional goal-content table was used to design the questions, which helped ensure content validity. As a result, the teacher-made tests were valid in terms of both form and content. Apart from the above, the opinions of sixth-grade experts and teachers with at least three years of teaching experience in this grade were also taken into consideration for the content validity of the test. They provided their feedback after carefully examining the teaching topic, test questions, and the two-dimensional table of goal-content. In the next step, the researcher applied the necessary feedback and corrected any incomplete items. As a result, the teacher-made test with 20 multiple-choice questions was finalized and used in the pre-test and post-test of learning. The reliability coefficient of the test questions was also calculated using Cronbach's alpha coefficient, which was found to be 0.81, indicating high reliability. The test was divided into two parts. The first part included receiving demographic information from the participants, along with instructions for completing the questions. The second part included questions and options related to each, and participants had to choose the correct option.

Design

This study aimed to investigate the effectiveness of blended learning based on electronic concept maps on students' social studies learning using a semi-experimental method. The research used a pre-test-post-test design with two experimental and control groups.

Procedure

The content of the electronic concept maps was designed using the content of the textbook "Social Studies of the sixth-grade," written by the Ministry of Education and the Educational Research and Planning Organization with code 607. First, conceptual maps were handwritten on paper. In the next step, qualitative content analysis was used and the sixth-grade teachers were asked to express their opinions regarding the degree of appropriateness and conformity of the content of the concept maps with the objectives of each lesson in a range from 1, the most appropriate, to 4 the least appropriate. After receiving the necessary feedback, some parts of the maps were changed and the necessary corrections were applied and again presented to the teachers to confirm the content. After experts' approval, the maps were designed using PowerPoint software and prepared for use in teaching. In this study, after selecting the sample, the participants were divided into two groups of 30 people. The intervention program was then conducted on the experimental group for 20 sessions that lasted 45 minutes each. Before the intervention, a pre-test was administered for both the experimental and control groups to compare their social studies learning. During the intervention sessions, the students in the experimental group were encouraged to ask questions and actively participate in discussions to ensure their full understanding of the subject and related concepts. The teacher also asked questions to test the students' knowledge and make sure they had learned the content. After each session, the images of the concept maps were re-uploaded in the students' class groups on the "Shad" student network so that the students could refer to them if needed. At the end of the intervention, a learning post-test was conducted, and the results were recorded. The data was analyzed using SPSS version 24 software, where descriptive analysis and covariance analysis tests were performed. A summary of the intervention sessions is presented in Table 1.

Ethical considerations were observed in the research, and all participants, including teachers and students, were given necessary explanations regarding the goals and process of the research. The students were assured that their participation was optional, and all pre-test-post-test results and information would be kept confidential. It should be noted that a few students from both classes were excluded from the research process due to various reasons, such as illness, unwillingness, or being under medical treatment.

Results and Findings

The demographic information of the research is presented before starting the statistical analysis and checking the research hypothesis. It is noted that all participants in the research were boys who were in elementary school and were between 11 and 12 years old. The study had 30 participants in the experimental group, which amounts to 50%, and 30 participants in the control group, also equal to 50%. In addition to descriptive statistics, inferential statistics were used to analyze the data. Analysis of covariance was used in the context of the learning variable, taking into account the pre-test used before the implementation of the experimental plan, the assumption of the homogeneity of the variance of the groups, and the normality of the investigated data.

The research hypothesis was: The application of blended learning based on concept maps is effective for students' learning of social studies. Below, the descriptive indices (mean and standard deviation) of the social studies learning variable for both the experimental groups and the control group are shown. The experimental group received a combined learning approach based on concept maps, while the control group was trained in the usual way. This information will help us understand the impact of the different training methods on social studies learning.

As can be observed from Table 2, there has been a noticeable improvement in the average scores of the social studies learning variable in the experimental group during the post-test phase when compared with the pre-test phase. This improvement can be attributed to the investigation of the effectiveness of combined training using conceptual maps through covariance analysis. To provide a comprehensive understanding of the test's reliability, the assumptions and results of the covariance analysis test are presented in the following tables.

- Examining the assumption of normality of data distribution related to learning variable scores: After conducting the Shapiro-Wilk test to check the normality of the distribution of scores for the dependent variables, the results were analyzed and are now displayed in Table 3. It's important to ensure that the data is normally distributed in order for accurate analysis and interpretation of the results.

The analysis in Table 3 indicates that the learning variable has a normal distribution, as the significance level is greater than 0.05. This confirms the assumption of normality of the data, which is further supported by the Shapiro-Wilk test.

- Examining the presumption of equality of variances related to the learning variable: Levine's test was used in order to check the assumption of homogeneity of variance of social studies learning variable scores. The results of this test are shown in Table 4:

Table 1: The main themes, objectives, and concepts discussed in each session [45]

Main Theme	Objectives	Session	The corresponding actions
Research plan	Introduction of the study plan	1	Getting to know the teachers and students, explaining the generalities, objectives, and research process for them, creating motivation, and necessary explanations.
Clothing	Types of Clothing	2,3	The role of clothing in representing social and occupational groups was mentioned. The impact of climate on clothing types was discussed. The history of Iranian clothing and traditional local attire was also considered.
	Clothing: Production Stages	4,5	The production of clothing in the past and present was compared. The concept of mass production was introduced, and important points in choosing work attire were discussed.
Seas	Iranian seas	6,7	The seas of the country, such as the Persian Gulf, the Caspian Sea, and the Sea of Oman, were introduced.
	The importance of the seas	8,9	The importance of the sea in terms of commerce, tourism, food sources, and energy sources was discussed, and concept maps were created with the help of students.
Adjacent Countries	our neighbors	10,11	The concepts of borders and how they are determined, the types of relationships with our neighbors, and the similarities between us and our neighbors were discussed and examined.
	Case study	12	The characteristics of two of the country's neighbors, such as Turkey and Afghanistan, were comprehensively studied (preparation of concept maps by students in groups and criticism and evaluation by students and feedback by the teacher).
Foreigners	colonialism	13,14	The phenomenon of colonialism, the reasons for Europe's advancement, and the influence of colonialism in Iran were examined.
	Anti-Colonial Struggle	15,16	Important figures in the fight against colonialism and the timeline of their efforts were discussed.
Khorramshahr	Occupation of Khorramshahr	17,18	A concept map related to the causes of Iraq's invasion of Iran and the occupation of Khorramshahr was prepared and discussed in class.
	Liberation of Khorramshahr	19,20	The liberation of Khorramshahr and the forces involved in its liberation were discussed.

Table 2: Descriptive indices of two experimental and control groups in the pre-test and post-test of the learning variable

Variable	Test	Experiment		Control	
		Mean	S. D	Mean	S. D
learning	Pre-test	6.13	2.17	6.87	2.48
	Post-test	14.70	3.62	12.67	2.80

Table 3: Shapiro-Wilk test for normality of data

Variable	group	Test statistics	df	sig
learning	Experiment	0.974	60	0.222
	Control	0.973	60	0.211

Table 4: The results of Levin's test to examine the homogeneity of variances of the learning variable

Variable	group	Levine's Test	df_1	df_2	sig
learning	Pre-test	0.738	1	58	0.394
	Post-test	2.5	1	58	0.119

Based on the above table, it can be concluded that the learning variable did not have a significant impact on the experimental and control groups. The p-value was greater than 0.05 (p-value > 0.05), indicating that the null hypothesis cannot be rejected at the significance level of 0.05. Therefore, it can be established that there is homogeneity of the variance of the scores in the mentioned variable. This means that the pre-test had the same effect on both groups. The statistical test of covariance analysis was implemented by considering all the necessary assumptions, and the results are presented in Table 5.

The analysis of covariance revealed that the experimental and control groups had a significant difference in their average scores ($F_{(57,1)}$ =60.13, p<0.005, partial $η^2$=19.2%). After adjusting for the pre-test scores, the use of blended learning based on conceptual maps explained 19.2% of the variance in the post-test scores. Additionally, the group variable showed that there was a significant difference between the average scores of the experimental and control groups after removing the pre-test effect. This suggests that blended learning focusing on conceptual maps has a positive impact on social studies learning among students.

Discussion

In this study, the effectiveness of blended learning centered on conceptual maps on the learning of social studies in the sixth grade was investigated, and the results indicated the effectiveness of this method. It seems that the research hypothesis has produced some positive results. The study suggests that using blended learning and conceptual maps has a significant impact on the learning outcomes of sixth-grade elementary students, specifically in the field of social studies. It's important to note that learning is a complex process that requires continuous improvement of teaching methods to keep learners engaged and motivated. This approach can lead to better academic progress and more sustainable changes in learners over time [15] [35,36]. The pandemic has definitely highlighted the limitations of online education. It has become clear that online education alone is not sufficient to meet the needs of students. It is important to address these gaps and work towards a more balanced approach to education that incorporates both online and offline learning [6,19]. While online education has its limitations, it's also apparent that traditional face-to-face education is not sufficient for today's digital-native students. Teachers are expected to incorporate technology in their teaching methods in order to enhance the learning experience. This is where blended learning comes into play. By combining both face-to-face and online education, blended learning aims to improve the effectiveness of teaching and learning while also catering to individual differences, different learning styles, and making it more accessible for students. Additionally, it can help reduce costs and provide more flexibility [1].

Table 5: The results of the covariance analysis to compare the average of two groups

Source of changes	square of squares	df	mean square	F	sig	$Ŋ^2$
Corrected model	254.307	2	127.153	17.394	0.000	0.379
Fixed effect	495.482	1	495.482	67.780	0.000	0.543
pre-exam	192.290	1	192.290	26.305	0.000	0.316
group	99.229	1	99.229	13.574	0.001	0.192
error	416.677	57	7.310	17.394		
Total	11905	60				

Blended learning offers a great way to combine the benefits of face-to-face education with the advantages of educational technology. It strengthens the effectiveness of teaching and learning by integrating constructive interactions in physical environments with the capabilities of educational technologies. This method provides a more effective approach to cover the disadvantages of both traditional and online education [24,25]. The research conducted by Rostaminezad et al. [35,36], Ma and Lee [22], Islam et al. [46], Ibrahim and Nat [28], Hrastinski et al. [27], and Salehinejad et al. [5] have all shown consistent results that support the effectiveness of blended learning.

The blended learning model used in this research seems to be a great way to enhance traditional education. It combines face-to-face classroom learning with electronic learning, which can provide students with a more comprehensive learning experience [24]. Blended learning is a teaching method that can be tailored to suit the learning styles of individual learners. This approach involves redesigning the teaching-learning process with the use of technology, to create a more effective and personalized learning experience for students [1]. It is an effective teaching method that uses modern educational technologies to make learning more engaging and interactive. By creating attractive content and improving students' attention and motivation, blended learning can help students achieve academic success more effectively [35,36,43]. These results are in line with the findings of Rostaminezad et al. [1] [35,36], Graham [24,25], Jabraili et al. [33], and Ma and Lee [22].

Also, the social studies course is indeed a crucial subject in elementary school, and it plays a significant role in shaping an individual's personality and understanding of human interactions. It not only provides knowledge about society and culture but also teaches important life skills like empathy, communication, and critical thinking. Overall, the importance of the social studies course cannot be overstated, and it should be given due attention in the curriculum [38]. The study findings suggest that using a combination of conceptual maps and blended learning can lead to more effective learning outcomes. This approach helps learners expand their understanding of social interactions with peers by re-conceptualizing learning patterns, which is in line with Wenger's "scientific societies" theory. It's fascinating to see how innovative teaching methods can enhance the learning experience. According to Wenger's theory, learners and teachers are seen as members of a group who collaborate and construct knowledge together through continuous interaction. This approach places a strong emphasis on learning rather than simply providing content. To facilitate this collaborative learning process, technology is often utilized to bring together the three key elements of cognition, education, and community, thereby enhancing the richness of the learning experience. Additionally, the constructivist approach can also be used to increase human interactions among learners, including group discussions and interactions. This approach can be especially beneficial for shy students, as it can help them become more involved in class discussions and engage more actively in the learning process. In these approaches, students are encouraged to take more responsibility for their own learning and to construct knowledge through meaningful and active engagement. This finding is consistent with the results of several other studies, including those conducted by samiee zafarkandi [29], Romero et al. [43], and Yar Mohammadi Vasel [44].

Studies have shown that teaching with the help of concept maps using a blended approach leads to the improvement of learners' learning [37]. The graphic view of information that concept maps provide can be a great way for students to organize, communicate and combine information. It's amazing to see how effective these tools can be in the teaching process and in promoting meaningful learning [42]. Concept maps are a great way to stimulate the mind and promote meaningful learning by using colors, images, and connections between concepts. These graphic structures are also very useful in evaluating students' understanding and linking the content to their cognitive development [39]. As the teaching and learning approaches have shifted from being teacher-centered to student-centered, there has been an increasing emphasis on using concept maps as an active approach to engage students' lateral thinking. It's amazing to see how effective these tools can be in promoting student-centered learning and encouraging students to think outside the box [34]. These results are also consistent with the results of Samiee Zafarkandi [29], Bardel and Mahmoudi [41], Owais [2], Selvi and Chandramohan [34], Pandey and Tyagi [42] and Rafiola et al. [40] is aligned.

Conclusions

The study aimed to analyze the effectiveness of blended learning with electronic concept maps for sixth-grade male students' social studies learning. The results of the covariance analysis indicated a significant difference between the experimental and control groups' average scores after adjusting for pre-test scores. In other words, blended learning, especially with a focus on conceptual maps, has a meaningful impact on student learning, as confirmed by the results of the analysis.

Among the limitations of the current research, we can mention experimental interventions by the researcher, which can influence the bias of the results. Not having a follow-up phase was another limitation of the above study. Therefore, it is suggested that other researchers, by removing the mentioned methodological limitations and also applying other variables affecting learning, should try to conduct new research with different societies and sample sizes, in other subjects and levels of study, and with different genders. This increases the accuracy of the results and increases the generalizability of the results. Based on the results obtained from the present study, it is possible to hold workshops and training courses in order to enable colleagues to use electronic concept maps and use them in teaching. In addition to the above, electronic concept maps can be used in the teaching-learning process in the curriculum of the second elementary school. An effective method is to use a combination of work and technology courses, social studies, and art. In addition to strengthening learning, this can also be effective in developing students' aesthetic sense. Finally, using technological literacy in the design of concept maps and encouraging students to use it during class presentations can be considered as other practical suggestions that strengthen the motivation of students to progress.

Authors' Contribution

In the present study, Mr. Zabet contributed his expertise in report writing, data collection, and statistical analysis. Mrs. Asadzade also played a vital role in the study with her proficiency in writing and data collection, report writing, and teaching. Additionally, Dr. Rostaminezhad's skills in statistical analysis and report review were crucial in conducting the reforms. Their cooperative efforts ensured the success of the study.

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Conflict of Interest

The authors have no conflicts of interest

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ORIGINAL RESEARCH PAPER

Investigating the Mediating Role of Teachers' Digital Literacy in the Relationship Between E-Learning and Instructional Interactions in Elementary Schools in Tehran

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ABSTRACT

Background and Objectives: The rapid advancements in information and communication technologies (ICT), along with their integration into mobile devices, have transformed the landscape of education, introducing innovative methods for teaching and learning. This technological integration has significantly influenced how the learning process is conceptualized and guided. Teachers, as the primary facilitators of learning, play a pivotal role in engaging students in virtual learning environments. However, the effectiveness of e-learning in fostering teacher-student interactions is contingent upon several factors, one of the most critical being teachers' digital literacy. Digital literacy not only determines teachers' ability to utilize e-learning tools effectively but also enhances their capacity to foster meaningful instructional interactions. The aim of this study was to investigate the mediating role of teachers' digital literacy in the relationship between e-learning and instructional interactions in elementary schools in Tehran.

Materials and Methods: The research was applied in nature, with a survey-based approach adopted for data collection. The statistical population consisted of 20,968 elementary school teachers across all 19 educational districts in Tehran. Of this total, 18,824 were female and 2,144 were male. Based on Morgan's table, the sample size was estimated at 376. A multi-stage cluster sampling method was employed. Initially, Tehran was divided into five geographical regions (north, south, center, east, and west). After dividing Tehran into these geographical regions, one cluster (region) was randomly selected from each region by assigning a code. In the subsequent stage, 20 clusters (schools) were randomly selected from each chosen region by assigning codes to ensure balance among the regions. To measure the variables under study, three validated instruments were employed: the Digital Literacy Questionnaire, E-Learning Questionnaire, and Teacher-Student Interaction Questionnaire. These tools provided a comprehensive framework for assessing teachers' digital literacy, the efficacy of e-learning, and the quality of teacher-student interactions. Structural equation model and linear regression were used to analyze the hypotheses.

Findings: The findings of the study underscore the significant positive impact of e-learning on teacher-student interactions. Furthermore, digital literacy was identified as a critical mediating factor that enhances this relationship. Specifically, the results demonstrated that teachers with higher levels of digital literacy were better equipped to leverage e-learning platforms, leading to more effective instructional interactions. The mediating role of digital literacy highlights its importance as a foundational skill that amplifies the benefits of e-learning technologies. This finding suggests that digital literacy not only facilitates the adoption of e-learning tools but also enriches the quality of teacher-student engagement in virtual learning settings.

Conclusions: The study's results emphasize the necessity of improving teachers' digital literacy to enhance the overall quality of education and promote effective teacher-student interactions in elementary schools. Digital literacy serves as a critical enabler, allowing teachers to navigate and utilize e-learning tools more effectively. Consequently, targeted interventions to improve teachers' digital literacy should be prioritized as part of broader educational reforms. Additionally, the development of ICT infrastructure within schools is imperative for the successful implementation of e-learning initiatives. Providing teachers with access to reliable digital tools and resources can further enhance their ability to deliver engaging and interactive virtual lessons. Moreover, tailored training programs focused on the practical use of e-learning platforms and digital teaching strategies can empower teachers to maximize the potential of ICT in education. By addressing these areas, schools can create a conducive environment for effective e-learning and foster stronger instructional interactions between teachers and students. The findings of this study contribute to the growing body of knowledge on the role of digital literacy in modern education and underscore its importance in adapting to the demands of the digital era.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
25	3	6

مقاله پژوهشی

بررسی نقش واسطه‌ای سواد دیجیتال معلمان در رابطه بین آموزش الکترونیکی و تعاملات آموزشی در مدارس ابتدایی شهر تهران

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چکیده

پیشینه و اهداف: پیشرفت‌های سریع در فناوری اطلاعات و ارتباطات (ICT) و ادغام آن‌ها در دستگاه‌های تلفن همراه، چشم‌انداز آموزش را متحول کرده و روش‌های نوآورانه‌ای را برای تدریس و یادگیری معرفی کرده است. این ادغام فناوری، نحوه تبیین و هدایت فرایند یادگیری را به‌طور قابل‌توجهی تحت تأثیر قرار داده است. معلمان، به‌عنوان تسهیل‌گران اصلی یادگیری، نقش محوری در جذب دانش‌آموزان در محیط‌های یادگیری الکترونیکی ایفا می‌کنند. با این حال، اثربخشی یادگیری الکترونیکی در تقویت تعاملات معلم و دانش‌آموز به عوامل متعددی بستگی دارد که یکی از مهم‌ترین آن‌ها سواد دیجیتال معلمان است. سواد دیجیتال نه تنها توانایی معلمان را در استفاده مؤثر از ابزارهای یادگیری الکترونیکی تعیین می‌کند، بلکه ظرفیت آن‌ها را برای ایجاد تعاملات آموزشی معنادار نیز افزایش می‌دهد. هدف این مطالعه بررسی نقش واسطه‌ای سواد دیجیتال معلمان در رابطه بین آموزش الکترونیکی و تعاملات آموزشی در مدارس ابتدایی شهر تهران است.

روش‌ها: روش تحقیق از نظر دست‌یابی به هدف از نوع کاربردی و از نظر شیوه گردآوری اطلاعات از نوع پیمایشی است. جامعه آماری به تعداد ۲۰۹۶۸ نفر معلم دوره ابتدایی در کل شهر تهران (مناطق ۱۹ گانه آموزش و پرورش شهر تهران) شامل ۱۸۸۲۴زن و ۲۱۴۴ نفر مرد بود. حجم نمونه براساس جدول مورگان ۳۷۶ نفر برآورد شد. روش نمونه گیری از نوع خوشه‌ای چند مرحله‌ای بود. در ابتدا شهر تهران به پنج منطقه جغرافیایی (شمال، جنوب، مرکز، شرق و غرب) تقسیم شد. پس از تقسیم‌بندی شهر تهران به مناطق جغرافیایی با دادن کد به‌صورت تصادفی از هر منطقه یک خوشه (منطقه) انتخاب شد. در مرحله بعد به‌صورت تصادفی از مناطق انتخابی با دادن کد از هر منطقه ۲۰ خوشه (مدرسه) به جهت رعایت توازن در مناطق انتخاب شد و برای اندازه‌گیری متغیرهای مورد مطالعه، سه ابزار معتبر مورد استفاده قرارگرفت که عبارتند از: پرسش‌نامه سواد رایانه‌ای، پرسش‌نامه یادگیری الکترونیکی و پرسش‌نامه تعامل معلم و دانش‌آموز. این ابزارها چارچوبی جامع برای ارزیابی سواد دیجیتال معلمان، اثربخشی یادگیری الکترونیکی و کیفیت تعاملات معلم و دانش‌آموز فراهم کردند. برای تحلیل فرضیات از مدل معادلات ساختاری و رگرسیون خطی استفاده شد.

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واژگان کلیدی:
یادگیری الکترونیکی
تعاملات آموزشی
سواد دیجیتال
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یافته‌ها: یافته‌های این پژوهش تأثیر مثبت یادگیری الکترونیکی بر تعاملات معلم و دانش‌آموز را تأیید می‌کند. علاوه بر این، سواد دیجیتال به‌عنوان یک عامل میانجیگری حیاتی شناسایی شد که این رابطه را تقویت می‌کند. به‌طور خاص، نتایج نشان داد که معلمان با سطح سواد دیجیتال بالاتر، مجهزتر به استفاده از سکوهای یادگیری الکترونیکی هستند و منجر به تعاملات آموزشی مؤثرتر می‌شوند. نقش میانجیگری سواد دیجیتال اهمیت آن را به‌عنوان یک مهارت بنیادین که مزایای فناوری‌های یادگیری الکترونیکی را تقویت می‌کند، برجسته می‌کند. این یافته نشان می‌دهد که سواد دیجیتال نه تنها پذیرش ابزارهای یادگیری الکترونیکی را تسهیل می‌کند؛ کیفیت تعامل معلم و دانش‌آموز را نیز در محیط‌های یادگیری مجازی غنی می‌سازد.

نتیجه‌گیری: نتایج این پژوهش بر ضرورت بهبود سواد دیجیتال معلمان برای ارتقای کیفیت کلی آموزش و ترویج تعاملات مؤثر معلم و دانش‌آموز در مدارس ابتدایی تأکید می‌کند. سواد دیجیتال به‌عنوان یک توانمندساز حیاتی عمل می‌کند و به معلمان امکان می‌دهد تا ابزارهای یادگیری الکترونیکی را مؤثرتر هدایت و استفاده کنند. در نتیجه، مداخلات هدفمند برای بهبود سواد دیجیتال معلمان باید به‌عنوان بخشی از اصلاحات آموزشی گسترده‌تر در اولویت قرار گیرد. علاوه بر این، توسعه زیرساخت‌های ICT در مدارس برای اجرای موفقیت‌آمیز ابتکارات یادگیری الکترونیکی ضروری است. فراهم کردن دسترسی معلمان به ابزارها و منابع دیجیتال قابل‌اعتماد می‌تواند توانایی آن‌ها را در ارائه درس‌های مجازی جذاب و تعاملی بیشتر تقویت کند. علاوه بر این، برنامه‌های آموزشی متناسب با تمرکز بر استفاده عملی از سکوهای یادگیری الکترونیکی و استراتژی‌های تدریس دیجیتال می‌تواند معلمان را برای به حداکثر رساندن پتانسیل ICT در آموزش توانمند کند. با رسیدگی به این حوزه‌ها، مدارس می‌توانند محیطی مناسب برای یادگیری الکترونیکی مؤثر ایجاد کرده و تعاملات آموزشی قوی‌تر بین معلمان و دانش‌آموزان را تقویت کنند. یافته‌های این مطالعه به مجموعه رو به رشد دانش در مورد نقش سواد دیجیتال در آموزش مدرن کمک می‌کند و اهمیت آن را در سازگاری با نیازهای عصر دیجیتال برجسته می‌سازد.

Introduction

In recent years, the global shift toward digital transformation in education has led to the emergence of new teaching approaches and learning paradigms. E-learning, as a significant advancement in educational technology, enables educators and students to engage in flexible and interactive environments that transcend physical limitations [1]. However, the effectiveness of e-learning largely depends on teachers' preparedness and their ability to adapt to these new environments, particularly in terms of digital literacy and digital competency [2]. The rapid advancements in information and communication technologies (ICT) and the proliferation of e-learning have driven educational environments towards digital interactions. This transformation necessitates that teachers possess adequate digital literacy to effectively utilize technology in teaching.

Teachers play a crucial role in fostering student engagement in e-learning activities. In the 21st century, educators must adapt to emerging needs, including the integration of information and communication technology (ICT) into their teaching practices. The use of ICT poses challenges in both traditional classroom settings and online environments, referred to as e-learning. Teachers are expected to use ICT to enhance students' learning experiences, guide their progress, provide solutions to potential problems, and support students in exploring and integrating new ideas [3]. E-learning refers to education delivered through electronic communication tools such as the internet, intranets, extranets, and hypertext. In the information age, e-learning has become one of the most prominent forms of learning, and its application in schools—particularly in Tehran—has expanded significantly [4]

Teacher-student instructional interactions, which lie at the heart of effective education, are influenced by various factors, including teachers' computer literacy. Digital literacy refers to an individual's ability to effectively use computers and technology. This includes skills such as navigating computer programs, leveraging digital tools, and utilizing technology in the learning process. In developed countries, basic computer skills were already considered an asset by 2005 [5].

In traditional classrooms, teacher-student interactions involve direct communication, emotional support, and collaborative problem-solving [6]. However, the shift to virtual learning environments has introduced new complexities, as technology-mediated interactions may lack the immediacy and depth of face-to-face communication. Studies have shown that inadequate digital literacy among teachers can exacerbate these challenges, undermining the potential of e-learning platforms to facilitate meaningful interactions [7]

Theoretical frameworks such as Vygotsky's Sociocultural Theory and Bandura's Social Learning Theory emphasize the critical role of interaction and collaboration in learning. According to Vygotsky [6], learning occurs through social interaction within the "zone of proximal development," which can be supported by digital scaffolding in e-learning environments. Similarly, Bandura [8] highlights observation and modeling as essential elements of learning, processes that can be facilitated through multimedia tools and virtual collaboration in technology-enhanced education [9]

Despite the growing adoption of e-learning in Iran, particularly in Tehran's elementary schools, there is limited empirical research on the specific role of teachers' digital literacy in mediating the effectiveness of e-learning in promoting teacher-student instructional interactions. This gap is particularly significant given the challenges faced by Iranian schools, such as insufficient teacher training, inadequate infrastructure, and resistance to change [4]

The selection of the study variables—e-learning, teachers' digital literacy, and instructional interactions—is based on their interdependent and complementary roles in enhancing educational quality:

- E-learning represents a transformative tool in contemporary education.
- Teachers' digital literacy serves as a mediating skill necessary for the effective use of e-learning.
- Instructional interactions between teachers and students reflect the quality of the teaching-learning process and are used as the study's outcome variable.

In essence, e-learning alone is insufficient. Without adequate digital literacy, teachers may not be able to leverage the potential of digital platforms. Digital literacy enhances the quality and depth of educational interactions in virtual settings. The selection of these variables is also supported by previous studies and aligns with the educational needs of the country.

The increasing reliance on e-learning worldwide, especially in response to global disruptions such as the COVID-19 pandemic, highlights the urgency of understanding its dynamics and limitations. This research holds substantial significance for several reasons:

- Addressing Educational Gaps: By exploring the mediating role of computer literacy, this study aims to bridge gaps in teacher-student interactions, ensuring that e-learning achieves its intended outcomes in Tehran's elementary schools.

- Practical Implications: The findings will offer actionable insights for policymakers and school administrators to design targeted teacher training programs, improve digital infrastructure, and create supportive environments for e-learning.

- Theoretical Contributions: By integrating theoretical insights from Vygotsky and Bandura with empirical evidence from the Iranian educational context, this study offers a localized perspective on global challenges, enriching the existing body of literature.

The theoretical significance of this study lies in its attempt to explain the role of teachers' digital literacy in enhancing educational interactions, drawing on Vygotsky's sociocultural theory and Bandura's social learning theory. Given the importance of teacher-student interactions in learning, this research holds significant theoretical implications.

This research aims to explore three interrelated variables in order to provide practical insights for improving the quality of education in Tehran’s elementary schools. The significance of the study lies both in its theoretical contribution—by offering a locally adapted conceptual framework based on international theories—and in its practical value, by proposing strategies for empowering teachers.

Therefore, the central problem addressed in this study is that e-learning in elementary schools, when implemented without considering teachers’ level of digital literacy, fails to foster effective and meaningful teacher-student instructional interactions. Therefore, the primary research question is: Does teachers’ digital literacy mediate the relationship between e-learning and instructional interactions with students in elementary schools in Tehran?

Review of the Related Literature

Asare et al. [2] In a systematic review, investigated the effect of incorporating information technology in English language teaching in higher education settings. With the rapid growth of technology, its integration into education has attracted considerable attention. Bagherzadeh Homaee explored the influence of online education on teaching-learning interactions, finding that effective integration of e-learning platforms improved the quality of communication between teachers and students, provided that users had sufficient familiarity with digital tools [7].

Reich studied teacher-student relationships in digitally enriched environments, demonstrating how virtual learning spaces enabled collaboration, emotional support, and cultural exchange, thus fostering intellectual growth among participants [1]. Masoumi Fard conducted a study on the relationship between various types of interaction in e-learning and collaborative learning quality. The findings indicated a significant and direct correlation between different types of interactions (teacher-student, student-student, student-content, teacher-content, teacher-teacher) and collaborative learning quality in e-learning. However, no significant correlation was found between content-content interaction and collaborative learning quality [10]

Kahrizi et al. carried out a study titled "Assessing the Digital Literacy Level of Middle School Teachers." The research results revealed that, on average, teachers rated their digital literacy below the average level. Their proficiency in using the internet and Word was higher than in other general computer skills. No significant correlation was found between digital literacy levels and demographic characteristics such as gender, teaching experience, and educational background [5]. Mohammadi Baghmaleki and Yousefi conducted a study on the structural relationship between teacher-student Interaction, academic engagement, and student adjustment to school. The findings indicated that teacher-student interaction had a direct effect on students' academic engagement and adjustment to school. The indirect effect of teacher-student interaction on school adjustment, mediated by academic engagement, was also significant [11]

Moradi Mokhles et al. compared interaction levels in computer-based and web-enhanced learning environments. Their findings indicated that web-enhanced platforms provided superior opportunities for collaboration, particularly in teacher-student and peer interactions [8]. Jokar and Khase highlighted media literacy as a critical factor in the success of e-learning implementations. They emphasized the need for teacher training in digital tools to maximize the benefits of e-learning [4]. Kashvarz et al. conducted a study to investigate the digital literacy standards in virtual education. Their findings revealed that faculty members exhibited a relatively satisfactory level of proficiency in fundamental IT concepts, operating system management, and software applications such as Word, PowerPoint, Access, and Excel. Moreover, their internet usage skills were deemed satisfactory. The overall digital literacy score was also found to be at a reasonably good level [12]

Mansouri investigated the types of interactions between students and the curriculum in virtual environments. The results indicated that blogs were the most commonly used tool by students for both academic and non-academic purposes. Regarding interaction topics, the findings showed that the curriculum variable had a limited role in students' virtual interactions, as most students engaged primarily in recreational activities online [13]. Misbah et al. explored the relationship between teacher interpersonal behavior and student motivation in competency-based vocational education, using evidence from Indonesia. The results showed that teacher profiles in CBE and less-CBE schools were comparable, except for one unexpected difference in a specific dimension. Perceived teacher interpersonal behavior moderated the relationship between CBE and student motivation, with a greater impact in less-CBE learning environments. The necessary changes in the teacher's role remain unclear, hindering expectations of increased motivation in competency-based education [14].

Van den and colleagues investigated student engagement, focusing on the role of teacher beliefs and interpersonal teacher behavior in enhancing student interaction in vocational education. The study identified three distinct components of interaction: behavioral, emotional, and cognitive. The strongest relationships were found between the two dimensions of interpersonal teacher behavior and the three components of student interaction [15]. Bodur et al. focused on the role of teachers in web-enhanced learning environments in elementary schools. Their study underscored the importance of teacher guidance in overcoming the challenges of virtual learning platforms, particularly for younger students [3].

The reviewed literature highlights the significant role of digital literacy and technology-enhanced environments in fostering teacher-student interactions. Both national and international studies underscore that e-learning can bridge educational gaps by enhancing collaboration and engagement, provided that educators possess the requisite digital skills.

The studies reviewed exhibit similarities to the current research. For instance, Baqerzadeh et al [16], Baqerzadeh Hamaei [8], and Masoumi Fard [10] explored electronic learning and its impact on the quality of education, similar to the present study. However, a key distinction lies in the fact that none of these previous studies examined the impact of electronic learning on teacher-student interactions, nor did they investigate the mediating role of teacher computer literacy. This novel aspect sets the current research apart, contributing to the field by exploring the unique relationship between electronic learning, teacher computer literacy, and instructional interactions. However, few studies have specifically investigated the mediating role of teachers' digital literacy in the context of elementary schools, particularly in Tehran. Moreover, prior research has not comprehensively explored how these interactions vary depending on varying levels of teacher digital competency.

The theoretical framework for this study is grounded in two prominent theories in education and learning sciences: Vygotsky's Sociocultural Theory and Bandura's Social Learning Theory. These frameworks provide a robust lens to understand the dynamics of e-learning and its influence on teacher-student interactions, with particular attention to the mediating role of computer literacy.

- Vygotsky's Sociocultural Theory: Vygotsky [6] emphasized the importance of social interaction as the foundation of learning and cognitive development. His concept of the Zone of Proximal Development (ZPD) is particularly relevant to e-learning environments. The ZPD refers to the difference between what a learner can achieve independently and what they can achieve with guidance from a more knowledgeable individual, such as a teacher.

In an e-learning context, digital tools and platforms can act as "scaffolds," facilitating the interaction between teachers and students within the ZPD. For instance, discussion forums, interactive simulations, and collaborative tools can enable teachers to provide tailored support to students, fostering deeper understanding and engagement. However, the effectiveness of such scaffolding relies heavily on teachers' computer literacy, as inadequate technological skills may hinder their ability to use these tools effectively [2]

Vygotsky's theory underscores that meaningful teacher-student interactions in e-learning require a deliberate effort to create socially interactive and cognitively enriching environments, mediated by technology.

- Bandura's Social Learning Theory: Bandura [8] proposed that learning occurs through observation, imitation, and modeling, which are particularly relevant in digitally mediated learning environments. He introduced the concept of reciprocal determinism, which suggests that personal factors (e.g., computer literacy), environmental factors (e.g., e-learning platforms), and behavior (e.g., teaching practices) interact dynamically.

In the context of e-learning, teachers model digital skills, collaborative behaviors, and critical thinking through their interactions with students. For example, a teacher adept at using multimedia tools can effectively demonstrate problem-solving techniques, inspiring students to replicate these behaviors in their learning processes. Bandura's theory highlights the need for teacher competence in technology to maximize the interactive potential of e-learning platforms [9]

Furthermore, Bandura emphasized self-efficacy, or an individual's belief in their ability to succeed in specific tasks. Teachers with high digital self-efficacy are more likely to engage with e-learning tools confidently, enhancing the quality of their interactions with students [2]

- Integrative Perspective: Combining these two theories provides a comprehensive framework for understanding the dynamics of e-learning and its impact on teacher-student interactions. Vygotsky's emphasis on social and collaborative learning complements Bandura's focus on modeling and self-efficacy. Together, they highlight the critical role of teachers' digital skills and confidence in facilitating interactive, effective e-learning environments.

For example, while Vygotsky emphasizes the need for scaffolding within the ZPD, Bandura explains how teachers' modeling of digital skills can encourage students to engage actively with e-learning platforms. Both theories underscore the importance of addressing teachers' digital literacy as a mediating factor in e-learning success.

Drawing upon Vygotsky's and Bandura's theories, this research investigates the relationship between e-learning (independent variable), teachers' digital literacy (mediating variable), and teacher-student interactions (dependent variable). In other words, the theoretical framework of this study is a combination of Vygotsky's and Bandura's theories: Vygotsky emphasized the role of technology in facilitating interactions within the zone of proximal development, while Bandura highlighted the teacher's role in modeling and reinforcing students' self-efficacy in digital environments.

Conclusion: This theoretical framework establishes that teacher-student interactions in e-learning environments are influenced by the interplay of social, cognitive, and technological factors. Drawing on Vygotsky's Sociocultural Theory and Bandura's Social Learning Theory, this study hypothesizes that teachers' digital literacy mediates the impact of e-learning on instructional interactions. This framework guides the research in exploring how these theoretical insights apply to elementary school teachers in Tehran.

Method

This study is classified as applied research based on its intended purpose. From a methodological perspective, it is a descriptive and correlational type, and from a data collection perspective, it is a survey study.

Participants

The statistical population consisted of 20,968 elementary school teachers across all 19 educational districts in Tehran. Of this total, 18,824 were female and 2,144 were male. Based on Morgan's table, the sample size was estimated at 376. A multi-stage cluster sampling method was employed. Initially, Tehran was divided into five geographical regions (north, south, center, east, and west). After dividing Tehran into these geographical regions, one cluster (region) was randomly selected from each region by assigning a code. In the subsequent stage, 20 clusters (schools) were randomly selected from each chosen region by assigning codes to ensure balance among the regions. The research variables are as follows: independent variable: e-learning; dependent variable: teacher-student interactions; mediating variable: teachers' digital literacy.

Instruments

To measure the variables under study, three validated questionnaires were used, each with confirmed reliability and validity based on previous research:

- Digital Literacy Questionnaire: Developed based on the instrument by Bagherpour et al. [17]. This tool evaluates teachers' ability to utilize digital technologies in educational contexts. The Cronbach's alpha coefficient for this questionnaire was reported to be 0.76.

- E-Learning Questionnaire: Adapted from the questionnaire designed by Elahi et al. [18], this instrument assesses the extent of teachers' use, competence, and application of e-learning tools. The Cronbach's alpha coefficient for this tool was 0.88.

-Teacher-Student Interaction Questionnaire: Based on the instrument developed by Lourdusamy and Khine [19], this questionnaire measures the quality of instructional interactions between teachers and students. The reliability of this tool was confirmed with a Cronbach's alpha of 0.91.

Face validity of the questionnaires was established by consulting a panel of experts in communication and educational sciences.

In this study, face validity was used to test the validity of the measurement tool; the questionnaire was approved by a panel of communication and educational science experts. The questionnaire's reliability was determined using Cronbach's alpha coefficient, as shown in Table 1:

Table 1: Cronbach's alpha coefficient of the research variables

Variables	Cronbach's alpha coefficients
E-learning	0.88
Teacher-student instructional interaction	0.91
Computer literacy	0.76

To measure the variables, the digital literacy questionnaire of Baqerpour et al. [17], the e-learning questionnaire of Elahi et al. [18], and the teacher-student interaction questionnaire of Lardosamy and Kenny [18] were used Data analysis

A Kolmogorov-Smirnov test was first used to test the normality of the data distribution in the inferential statistics section. The hypotheses were tested using structural equation modeling and linear regression due to data normality.

Results and Findings

Based on the research findings, 32.3% of the studied samples were men, while 62.7% were women. The lowest frequency of samples (10.8%) was over 50, while the highest frequency (34.5%) was between 30 and 40. Among the samples, 2.8% held an associate degree with the lowest frequency, and 52.6% held a bachelor's degree with the highest frequency. At the lowest frequency, 4.9% of the samples had more than 25 years of experience, while at the highest frequency, 27.1% had 5-10 years of experience. As a result, the average capability was 3.03, the average application was 3.10, and the average e-learning was 3.07. Among the e-learning dimensions, the application had the highest average, while the capability had the lowest average. Leadership was rated at 3.47, helpfulness-friendliness was rated at 3.79, understanding was rated at 3.24, student responsibility-freedom was rated at 3.90, uncertainty was rated at 2.30, dissatisfaction was rated at 3.11, admonishment was rated at 2.29, strictness was rated at 3.64, and teacher-student interaction was rated at 3.21. E-learning was rated 3.61 on average.

Hypothesis testing

Since the significance level of the test error at the 0.95 confidence level is higher than 0.05 (Table 2), it can be concluded that the distribution of the research variables is normal, and parametric tests can be applied to test hypotheses.

Main Hypothesis: "E-learning affects teacher-student instructional interactions through the mediating role of teachers' computer literacy."

Table 2: Kolmogorov-Smirnov test results to determine the normality of the research variable distribution

Statistics	Teacher-student instructional interactions	E-learning	Computer literacy
The z-statistic for the Kolmogorov-Smirnov test	0.81	0.98	0,94
Significance level	0.29	0.16	0.19

A path coefficient of 62% was calculated for the impact of e-learning on teacher-student instructional interactions, as shown in Fig. 2 and

Fig. 3. In addition, the t-value for this parameter was estimated at 4.65. Based on a t-value of 5.12, the path coefficient of the mediating effect of teachers' digital literacy on teacher-student instructional interactions was calculated at 69%.

The structural equation modeling of the main hypothesis

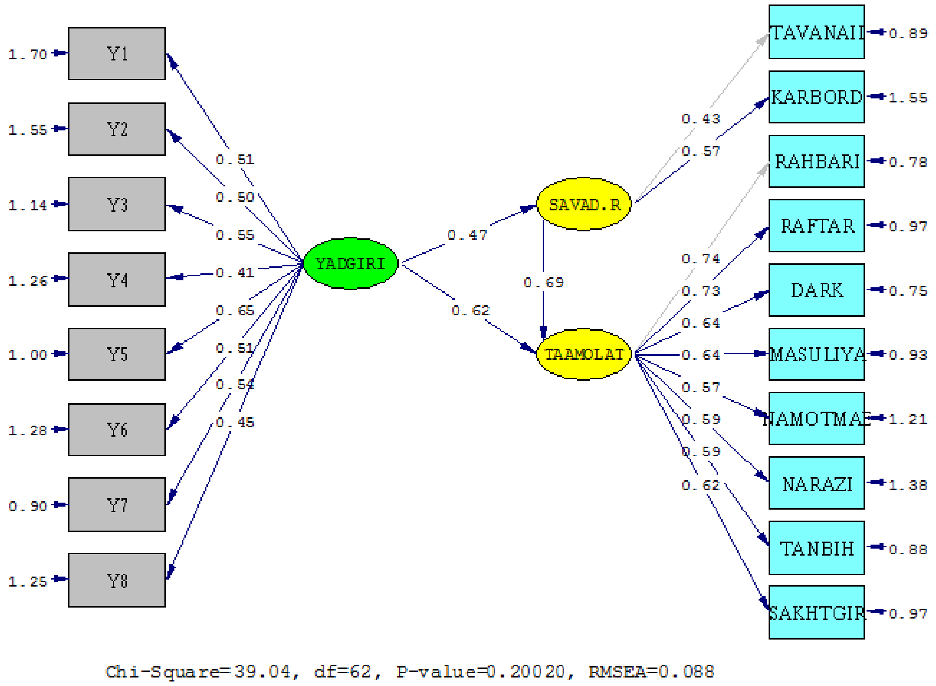

Fig. 1: The factor loadings for the main hypothesis

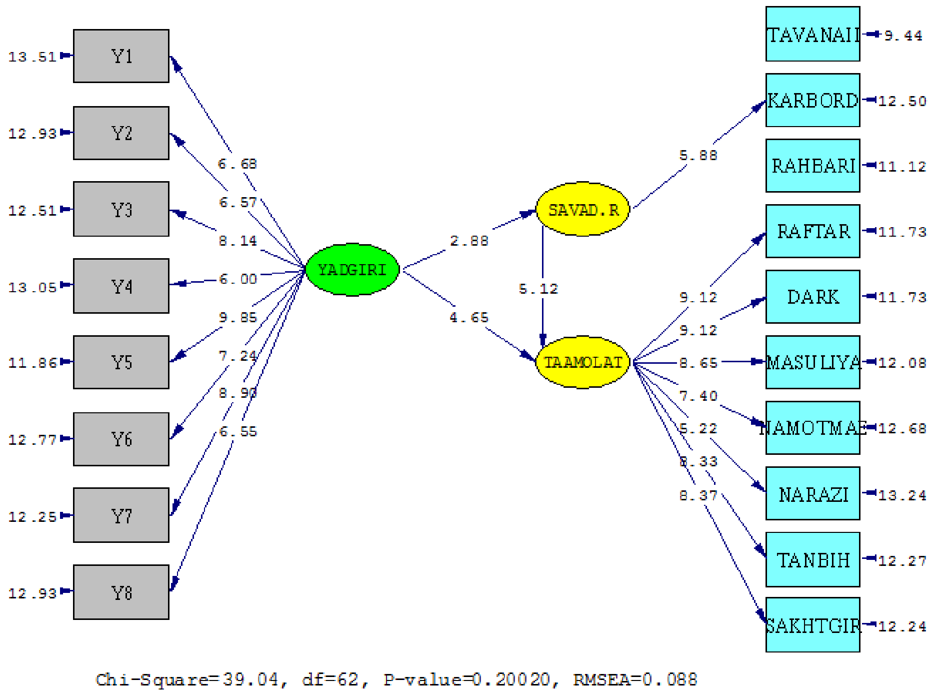

Fig. 2: T-values for analyzing the significance of the main hypothesis coefficients

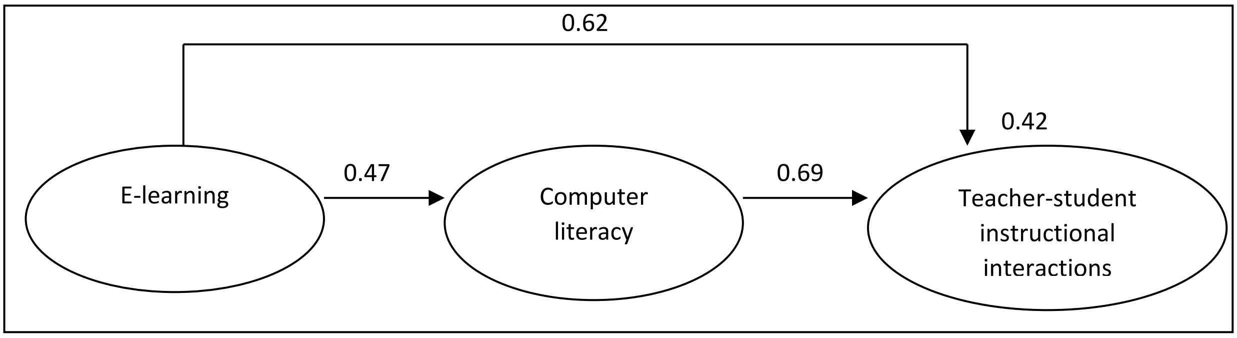

Fig. 3: The path coefficient of the main hypothesis

According to the path analysis shown in Fig. 3, e-learning and digital literacy explain 0.42% of the variance of teacher-student instructional interactions, with standard beta coefficients of 0.62 and 0.69, respectively. Therefore, the null hypothesis (H0) is rejected with a 99% confidence level. This coefficient is significant and positive, indicating that e-learning influences teacher-student interactions, with digital literacy playing a mediating role.

The findings of this study demonstrate that teachers' digital literacy plays a mediating role in the relationship between e-learning and teacher-student instructional interactions. As teachers' digital literacy increases, this effect will strengthen, and as teachers' digital literacy deteriorates, this relationship will weaken naturally. It is possible to infer this issue based on the significance and directionality of the effect of teachers' computer literacy. As a result, the main hypothesis is supported.

First sub-hypothesis: "E-learning significantly affects teacher-student instructional interactions."

Table 3: An overview of the regression model explaining the influence of e-learning on teacher-student instructional interactions

Correlation coefficient	R^2	Adjusted R^2
0.669	0.448	0.446

Table 3 shows a correlation coefficient of 0.66 and a coefficient of determination (R^2) of 0.44 between e-learning and teacher-student instructional interactions. Accordingly, e-learning accounts for 0.44 changes in teacher-student instructional interactions, while other variables account for 0.56 changes.

It can be concluded from Table 4 that, based on the significance level of the test error at a confidence level of 0.95, the first sub-hypothesis is supported, indicating that e-learning has a significant positive effect on teacher-student instructional interactions. Additionally, the BETA coefficient suggests that e-learning predicts 0.66 changes in teacher-student interactions.

Second sub-hypothesis: "Digital literacy significantly affects teacher-student instructional interactions."

Table 5 shows a correlation coefficient of 0.56 and a coefficient of determination (R^2) of 0.31 between digital literacy and teacher-student instructional interactions. Therefore, digital literacy accounts for 0.31 changes in teacher-student instructional interactions, while other variables account for 0.69 changes.

It can be concluded from Table 6 that, based on the significance level of the test error at a confidence level of 0.95, the second sub-hypothesis is supported, indicating that digital literacy has a significant positive effect on teacher-student instructional interactions. Additionally, the BETA coefficient suggests that digital literacy predicts 0.56 changes in teacher-student instructional interactions.

Discussion

The findings of this study underscore the importance of e-learning and teachers' digital literacy in shaping teacher-student instructional interactions in elementary schools in Tehran. By applying structural equation modeling and regression analysis, this research has provided valuable insights into the relationships between e-learning, computer literacy, and teacher-student interactions.

Interpretation of Findings

- E-Learning and Teacher-Student Interactions: The study reveals that e-learning significantly affects teacher-student instructional interactions. The path coefficient of 0.62 indicates a strong positive relationship, confirming that e-learning environments, when integrated effectively, foster better communication and engagement between teachers and students. This finding aligns with previous studies, such as Reich [19] which emphasized the role of virtual learning in enhancing collaboration and intellectual growth. The study also found that e-learning accounts for 44% of the variance in teacher-student interactions, which highlights its substantial impact on educational practices in virtual environments.

Table 4: The results of the simple linear regression equation examining the influence of e-learning on teacher-student instructional interactions

Predictor variable	Unstandardized coefficients		Standardized coefficients	T	P
	B	SE	BETA		
Constant number	1.944	0.140		13.853	0.000
E-learning	0.534	0.033	0.669	16.177	0.000

Table 5: An overview of the linear regression model explaining the influence of digital literacy on teacher-student instructional interactions

Correlation coefficient	R^2	Adjusted R^2
0.563	0.316	0.314

Table 6: The results of the simple linear regression equation examining the effect of digital literacy on teacher-student instructional interactions

Predictor variable	Unstandardized coefficients		Standardized coefficients	T	P
	B	SE	BETA		
Constant number	2.169	0.167		13.000	0.000
Computer literacy	0.497	0.041	0.563	12.229	0.000

- The Mediating Role of Computer Literacy: Another key finding is the mediating effect of teachers' digital literacy on the relationship between e-learning and teacher-student instructional interactions. A path coefficient of 0.69 suggests that the effectiveness of e-learning is significantly enhanced when teachers possess high levels of computer literacy. This is consistent with the findings of Keshavarz et al. [12] who demonstrated that teachers' digital competencies directly correlate with the quality of instructional interactions. As teachers' digital literacy increases, their ability to navigate digital tools, create interactive learning materials, and foster meaningful engagement in e-learning platforms improves. Conversely, lower digital literacy levels can hinder effective use of e-learning resources, diminishing the potential for impactful teacher-student interactions.

- The Influence of Computer Literacy: The study also established that digital literacy itself has a significant effect on teacher-student instructional interactions, accounting for 31% of the variance in these interactions. The positive relationship between digital literacy and teacher-student interaction is in line with prior research [7] which showed that teachers who are more proficient in using technology are better able to facilitate communication and collaboration in online learning environments. This finding supports the idea that digital literacy is a crucial factor in the successful implementation of e-learning.

The results of this study are consistent with several studies in the literature, which highlight the critical role of digital competencies in enhancing teacher-student interactions in e-learning environments. For instance, Keshavarz et al. [12] found that digital literacy was a key determinant of the effectiveness of virtual education. Similarly, Bagherzadeh Homaee [7] demonstrated that a strong command of digital tools enhances communication between teachers and students, particularly in online learning settings. Moreover, this study's findings resonate with Vygotsky's Sociocultural Theory, which posits that learning is a social process facilitated by interaction. The use of digital scaffolding in e-learning environments enables teachers to support students' learning within their Zone of Proximal Development, but this process depends on the teacher's technological competence.

Furthermore, Moradi Makhless and colleagues [9] suggested that web-based platforms create better opportunities for teacher-student interactions, which also aligns with this study's conclusion that digital tools enhance the interaction quality between teachers and students.

Vygotsky emphasized the significance of social interactions and the concept of the "Zone of Proximal Development" (ZPD), where learning occurs when an individual interacts with more experienced individuals, such as teachers. In this study, a key finding is that teachers' digital literacy and e-learning skills significantly affect the quality of teacher-student interactions. This aligns with Vygotsky's theory, as teachers' digital literacy serves as a form of "scaffolding" that facilitates students' learning in the virtual environment. When teachers lack adequate digital skills, however, these scaffolding opportunities are hindered, as shown by the finding that "low digital literacy among teachers negatively impacts educational interactions."

More specifically, effective use of digital tools such as online platforms helps create opportunities for social and educational interactions in digital spaces. However, if teachers' digital literacy is insufficient, these interactions remain suboptimal, mirroring Vygotsky's argument that social interactions are essential for cognitive development, which in turn requires adequate tools and scaffolding.

Bandura's Social Learning Theory also offers a relevant framework for understanding the dynamics of teacher-student interactions in e-learning. Teachers with high digital self-efficacy are better equipped to model effective use of technology, inspiring students to replicate these behaviors in their own learning processes. The findings of this study confirm the role of teacher competence in fostering engagement and collaboration in virtual learning environments.

Bandura's theory emphasizes learning through observation and modeling behaviors, particularly through the concept of "self-efficacy," which refers to an individual’s belief in their ability to perform tasks successfully. In this study, the role of teachers’ digital literacy as a key factor in improving educational interactions through digital modeling and independent learning is evident. These findings align with Bandura's theory because teachers, by demonstrating proficient use of digital tools, model effective behaviors for students and foster their self-efficacy in independent learning.

Based on the theoretical frameworks of Vygotsky and Bandura, the study findings can be analyzed as follows:

- Vygotsky’s Theory suggests that teachers act as mediators of development within the Zone of Proximal Development. In digital learning environments, this mediation occurs through providing opportunities for students to engage with digital learning tools, which require teachers to possess adequate digital literacy. Without such literacy, teachers cannot effectively scaffold students’ learning.
- Bandura’s Social Learning Theory posits that teachers, by demonstrating appropriate behaviors and using digital tools effectively, serve as role models for students, enhancing their self-efficacy. As the study shows, teachers’ digital literacy enables them to serve as effective role models, thus influencing students' ability to learn independently and with confidence.

Conclusions

This study supports the hypothesis that e-learning affects teacher-student instructional interactions through the mediating role of teachers' computer literacy.

In conclusion, the study suggests that teachers' digital literacy is crucial for enhancing educational interactions in digital learning environments. The findings underscore the importance of improving teachers' digital skills and providing adequate resources to foster positive learning outcomes in virtual settings. The study highlights a gap in the existing literature regarding the mediating role of digital literacy in elementary school contexts, particularly in Tehran, and contributes to filling this gap by emphasizing the role of teachers' digital skills in improving e-learning interactions in primary education. However, the study also highlights a gap in the literature—specifically, the limited empirical research focusing on the mediating role of digital literacy in elementary school contexts, particularly in Tehran. The findings of this study contribute to filling this gap by emphasizing the importance of teachers' digital skills in enhancing e-learning interactions in primary education.

This study has several practical implications for educational policymakers, administrators, and teacher educators:

- Teacher Training Programs: Given the mediating role of computer literacy, it is crucial to design targeted professional development programs that focus on enhancing teachers' digital competencies. Training should emphasize not only the technical aspects of using e-learning tools but also pedagogical strategies for fostering meaningful interactions in virtual learning environments.

- Infrastructure Development: The findings also point to the need for improved digital infrastructure in schools. As e-learning platforms become an integral part of education, it is essential to ensure that both teachers and students have access to reliable internet and modern devices that support the effective use of educational technologies.

- Curriculum Integration: The study suggests that integrating e-learning tools into the curriculum should be done in a way that complements traditional teaching methods. Educators should be encouraged to use a variety of digital tools to create interactive and collaborative learning environments, thus fostering more engaging and productive teacher-student interactions.

This research is limited to elementary school teachers in Tehran, and factors such as technological infrastructure or student motivation are not directly examined. The research focuses on three variables: e-learning, teachers' digital literacy, and teacher-student interactions. Other factors, such as student motivation or cultural influences, are not examined. While this study provides valuable insights, it has several limitations. First, the research was conducted in a specific geographical region (Tehran) and within a particular educational context (elementary schools). Future studies could extend the research to other regions and educational levels to enhance the generalizability of the findings. Additionally, the study relied on self-reported data, which may be subject to biases. Future research could incorporate more objective measures, such as classroom observations or assessments of teachers' digital literacy. Moreover, this study focused on teacher-student interactions in e-learning environments but did not examine the impact of student factors, such as digital literacy or motivation, on these interactions. Future research could explore the reciprocal influence of both teacher and student competencies in shaping the effectiveness of e-learning.

Author's Contribution

Conflicts of Interest

"No conflicts of interest were declared by the authors."

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ORIGINAL RESEARCH PAPER

Enhancing the Teaching of Longitudinal Relationship Theorems in Iranian High School Geometry: Integrating GeoGebra Software and Practical Examples

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ABSTRACT

Background and Objectives: This comprehensive study delves into the comparative effectiveness of diverse educational approaches in enhancing students' comprehension and learning skills, specifically in the domain of geometric theorem proofs. The research focuses particularly on the section related to longitudinal relationships within triangles, a crucial component of the 11th-grade geometry curriculum. To identify the most impactful teaching strategies, this investigation meticulously compares three distinct pedagogical methods: (1) using illustrated examples formulated by the researcher through GeoGebra software, (2) exclusive use of examples, and (3) adherence to traditional teaching methods.
Materials and Methods: This research employs a quasi-experimental design with two experimental groups and one control group, including pre-test and post-test assessments. In terms of its objective, it is considered an applied study. The study population comprised 332 female 11th-grade students from District 3 of Isfahan during the second half of the 2021-2022 academic year. For the selection of the statistical sample, 60 students from three schools in District 3 of Isfahan were chosen using a purposive sampling method. All participants completed Cattell's Culture Fair Intelligence Test and a pre-test in Geometry 1 with identical questions. The first experimental group received an instructional video on constructing simple shapes and measuring shape components using GeoGebra software, along with virtual instructions on effective software use. The first author addressed their issues in five one-hour sessions. Additionally, five practical examples related to longitudinal relationships in triangles from the 11th-grade geometry textbook were presented, with responses designed using GeoGebra. Content validity was ensured through feedback from five experienced professors and teachers, who also reviewed aspects such as adherence to Persian grammar. The test questions demonstrated good reliability (Cronbach's alpha = 0.81). Given that this number exceeded 0.7, the test questions demonstrate good reliability. After confirmation and correction, the examples were provided to both experimental groups consecutively over five weeks, with 90-minute sessions conducted in the classroom. Examples were given to students without answers. The first group used GeoGebra to solve examples, hypothesize relationships between components, and verify them. Subsequently, correct answers were provided, and students were required to infer and prove the principles of relevant theorems with teacher guidance. Data analysis was conducted using SPSS 25 software, including ANCOVA analysis, Kolmogorov-Smirnov test, and Levene's test.
Findings: ANCOVA (Analysis of Covariance) results revealed statistically significant differences among the groups. Notably, the primary experimental group, which utilized a combination of carefully selected examples and interactive GeoGebra software, demonstrated superior performance compared to the second experimental group. This enhanced performance was particularly evident in two critical areas of geometric understanding: the accurate identification of relevant geometric theorems and the subsequent application of these theorems to complex problem-solving scenarios.
Conclusions: This comprehensive research underscores the significant benefits of integrating examples and GeoGebra software in geometry education. The findings demonstrate that this combined approach not only enhances students' understanding but also fosters their creativity and promotes active participation in the learning process. By engaging with interactive, visual representations of geometric concepts, students are empowered to explore, hypothesize, and verify mathematical ideas independently. This increased

engagement ultimately leads to a more robust and lasting comprehension of geometric principles. It is recommended that educators actively encourage students to install GeoGebra software on their personal devices and allocate specific time for students to gain proficiency in its use.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
61	9	5

مقاله پژوهشی

تقویت آموزش قضایای روابط طولی در درس هندسه دبیرستان‌های ایران: تلفیق نرم‌افزار جئوجبرا و مثال‌های کاربردی

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چکیده

پیشینه و اهداف: این مقاله به بررسی اثربخشی رویکردهای آموزشی متمایز در افزایش درک و مهارت یادگیری دانش‌آموزان در اثبات قضایای هندسی، با تمرکز بر بخش مربوط به روابط طولی درون مثلث‌ها که بخش مهمی از برنامه درسی هندسه کلاس یازدهم است، می‌پردازد. این تحقیق به طور دقیق سه روش آموزشی متمایز را با هم مقایسه می‌کند: (۱) استفاده از مثال‌های مصور فرموله شده توسط محقق از طریق نرم‌افزار جئوجبرا، (۲) استفاده انحصاری از مثال‌ها، و (۳) پایبندی به روش‌های تدریس سنتی.

روش‌ها: این پژوهش یک طرح شبه‌آزمایشی با دو گروه آزمایش و یک گروه کنترل است که شامل پیش‌آزمون، پس‌آزمون و از نظر هدف کاربردی می‌باشد. دانش‌آموزان پایه یازدهم ریاضی را به سه گروه مجزا شامل دو گروه آزمایش و یک گروه کنترل تقسیم کردیم. جامعه آماری این پژوهش، کلیه دانش‌آموزان دختر پایه یازدهم دوره دوم متوسطه شهر اصفهان در ناحیه سه در نیمه دوم سال تحصیلی ۲۰۲۲-۲۰۲۱ به تعداد ۳۳۲ دانش‌آموز بود. برای انتخاب نمونه آماری ۶۰ دانش‌آموز از سه مدرسه ناحیه سه اصفهان از روش نمونه‌گیری هدفمند استفاده شد. همه گروه‌ها تحت آزمون هوش کتل سه مقیاسی با گروه آزمایشی اول قرار گرفتند. پیش‌آزمون هندسه ۱ شامل سؤالات یکسان برای همه گروه‌ها اجرا شد. گروه آزمایشی اول، فیلم آموزشی ساخت اشکال ساده و اندازه‌گیری اجزای شکل با استفاده از نرم‌افزار جئوجبرا به همراه دستورالعمل مجازی نحوه استفاده مؤثر از نرم‌افزار را دریافت کردند. نویسنده اول مقاله اشکالات آنها را در پنج جلسه یک‌ساعته رفع کرد. علاوه بر این، پنج مثال کاربردی مربوط به کتاب هندسه پایه یازدهم با تمرکز بر روابط طولی در مثلث‌ها ارائه شد. پاسخ آنها با استفاده از نرم‌افزار جئوجبرا طراحی شد. برای بررسی اعتبار محتوا در فرایند ساخت، از نظرات پنج استاد و معلم مجرب استفاده شد. مواردی مانند رعایت دستور زبان فارسی با اعمال نظرات و دیدگاه‌های پنج استاد و معلم مجرب بازنگری شد. برای تعیین پایایی سؤالات از ضریب آلفای کرونباخ استفاده شد و پایایی آن ۰/۸۱ بود. با توجه به اینکه این عدد بیش از ۰/۷ شد، سؤالات آزمون از پایایی خوبی برخوردار هستند. پس از تأیید و تصحیح، مثال‌ها به طور متوالی در طی پنج هفته در اختیار هر دو گروه آزمایشی قرار گرفت و جلسات ۹۰ دقیقه‌ای در کلاس درس انجام شد. مثال‌ها به دانش‌آموزان بدون پاسخ داده شد. گروه اول برای حل مثال‌ها، فرضیه‌سازی روابط بین اجزا و بررسی صحت آنها از نرم‌افزار جئوجبرا استفاده کردند. متعاقباً پاسخ‌های صحیح در اختیار ایشان قرار گرفت و موظف شدند با راهنمایی معلم اصل قضایای مربوطه را استنباط کرده و اثبات کنند. برای تجزیه و

تحلیل داده‌های به دســـت‌آمده از بخش اســـتنباطی نرم‌افزار SPSS 25 که شـــامل تحلیل آنکوا، آزمون کولموگروف اسمیرنوف، آزمون لون بود استفاده شد.
یافته‌ها: نتایج ANCOVA (تحلیل کوواریانس) تفاوت آماری معنی داری را بین گروه ها نشـان داد. شـایان ذکر اسـت، گروه آزمایش اول که از تلفیق مثالهای انتخاب شـده دقیق و نرم‌افزار تعاملی جئوجبرا اسـتفاده کردند، نسـبت به گروه آزمایشی دوم عملکرد بهتری از خود نشان دادند. این عملکرد بهبود یافته به ویژه در دو حوزه مهم درک هندسی مشهود بود: شناسایی دقیق قضایای هندسی مرتبط و کاربرد بعدی این قضایا در روشهای حل مسئله پیچیده.
نتیجه‌گیری: این تحقیق جامع بر مزایای قابل توجه ادغام مثال ها و نرم افزار جئوجبرا در آموزش هندســـه تاکید دارد. یافته‌ها نشـــان می‌دهد که این رویکرد ترکیبی نه تنها درک دانش‌آموزان را افزایش می‌دهد، بلکه خلاقیت آنها را نیز تقویت می‌کند و مشارکت فعال در فرایند یادگیری را ارتقا می‌دهد. با درگیر شدن با نمایش‌های تعاملی و بصری مفاهیم هندسـی، دانش‌آموزان تشـویق می‌شـوند که به طور مسـتقل ایده‌های ریاضـی را کشـف، فرضـیه‌سـازی و تأیید کنند. این درگیری بهبود یافته در نهایت منجر به درک قوی تر و پایدارتر از اصـول هندسـی می شـود. توصـیه می‌شـود که مربیان فعالانه دانش‌آموزان را تشویق کنند تا نرم‌افزار جئوجبرا را بر روی دستگاه‌های شخصی خود نصب کنند و زمان خاصی را به دانش‌آموزان اختصاص دهند. تا در استفاده از آن مهارت کسب کنند.

Introduction

Mathematics is a core scientific discipline with diverse branches, each with distinct characteristics. Algebra focuses on symbol manipulation and analytical problem-solving. Geometry emphasizes the mental visualization of shapes and spatial relationships. Statistics involves collecting, analyzing, and summarizing data [1]. Students' attitudes toward geometry significantly impact their progress and achievements. A positive outlook on geometry leads to greater dedication and commitment to excel [2]. Teachers play a vital role in education, responsible for developing scientifically literate individuals for the 21st century [3]. This influence is especially strong among geometry educators, reaching 80%.

Teachers support students facing learning challenges through scaffolding. As described by Wood [4], scaffolding involves an expert, like a teacher, assisting someone with less knowledge or expertise, such as a student. Scaffolding methods include cue cards, handouts, prompts, hints, examples, questions, narratives, explanations, visuals, and inquiry-based and problem-solving strategies [1]. Educators widely recognize problem-solving as essential to the mathematics curriculum. It should be taught alongside arithmetic skills, which are important for both academic and real-world success [5]. Developing problem-solving skills improves logical, critical, and creative thinking. It's considered a key life skill, involving analysis, interpretation, reasoning, prediction, evaluation, and reflection [6]. Traditional geometry instruction often relies on lectures with one-way communication, focusing on reading, writing, and discussion. However, integrating Information and Communication Technology (ICT) in education requires proficiency beyond these basic skills. In teaching and learning, ICT includes various multimedia technologies such as text, sound, graphics, animation, and simulators [7]. Most research on digital tools in mathematics education focuses on classroom settings, curricula, and school contexts [8]. Mathematics typically uses four main representation modes: (1) verbal, (2) graphical, (3) algebraic, and (4) numeric. While certain representations may be emphasized, transferring between modes remains important [9]. Digital math environments allow students to identify connections, properties, patterns, and rules by manipulating various representations [10]. Teachers' use of digital technology in classrooms depends on factors like personal beliefs, attitudes toward technology, and views on mathematical knowledge and learning [11].

The main goal is to create an environment where students discover mathematical structures through diverse software-aided representations, improving their understanding of concepts that are often difficult to grasp with traditional methods [12]. Geometry is particularly suited for trial-and-error activities [13]. Toluk notes that students are more likely to develop advanced skills when they're interested in the learning activities. Dynamic geometry software, like GeoGebra, can effectively build this interest [13]. These environments offer increased embodiment for technology-enhanced learning, with dragging actions providing motoric engagement and gestural congruency on touchscreen devices [14]. While some educators believe effective math teaching involves patience, repetition, exploration, explanation, and extensive practice [15], dynamic geometry software significantly contributes to learning. Teachers use their knowledge to choose appropriate technological applications, helping students tackle geometry problems. Selecting a suitable framework is key, allowing teachers to incorporate dynamic applications into active learning environments through careful planning [12].

Education that truly prepares students involves giving them chances to learn independently [16]. Constructivism sees students as active participants who build their own understanding. In this view, teachers guide and support, focusing on student-centered methods [17]. Constructivism puts the individual first in social learning, stressing learning over traditional teaching. It sees knowledge as personal interpretations from interacting with the world, with each person forming their own view of reality. Learning is active, based on experiences, and shaped by what someone already knows. The level of teamwork between teachers and students directly affects how much and how well students learn. Knowledge grows through individual interaction, interpretation, and self-reflection [18]. Both teachers and students take part in activities that fit with constructivist ideas. Windschitl outlined these roles for teachers:

- "Ask about students' beliefs and experiences on key concepts, then create ways for them to actively rethink what they know.
- Give students many chances to work on complex, meaningful problems.
- Help students talk about their work and collaborate with classmates.
- Provide various information sources and tools, including technology and visual aids, to support learning.
- Show students how they think through problems, and encourage students to share their thoughts through talking, writing, art, or other means.
- Often ask students to use what they've learned in new situations, explain their ideas, interpret texts, predict outcomes, and discuss using evidence.
- Use different ways to assess and give feedback on students' beliefs, thinking processes, and results [19]."

Teaching draws on various professional areas, including subject expertise, teaching methods, curriculum knowledge, and information literacy. It also requires cultural awareness and strong communication skills [20]. Education researchers support engaging students in tasks that involve creating and interpreting field-specific representations. They also recommend exposing students to new representations beyond those in typical textbooks [21]. Educational simulations can improve teaching by offering concrete depictions of abstract ideas, aiding understanding. These simulations let students interact with material at their own speed, using their existing knowledge to reshape their mental models [22]. Some simulations are exemplars, which help communicate, explain, and discuss ideas, especially in mathematics. Teachers use exemplars to help students generalize and build mathematical understanding [23]. Learning through examples isn't new; it's been studied in education for decades. From the 1950s to the 1970s, researchers used the learning-by-example approach to study concept formation [24]. Exemplars are crucial for student learning. Expanding knowledge depends on having various examples, knowing how to create them, strengthening their connections, and accessing them easily [23]. While the basis for a conjecture is sometimes clear, it's often not obvious. In these cases, mathematicians turn to examples to explore new problems [25].

Many factors influence teaching geometric drawing and reasoning. Teachers must balance these elements to maximize class effectiveness, using all available professional tools and knowledge [20]. Well-designed examples clearly communicate between learners, teachers, and abstract concepts. In math education, examples serve many purposes: understanding concepts, motivating, proving, reasoning, developing hypotheses, assessing, making connections, generalizing, fostering creativity, and problem-solving. Examples are central to teaching math concepts, advancing math education, and supporting teaching theories [26]. Two key factors in students' problem-solving skills are teaching methods and textbook choice [27]. Curriculum planners and textbook authors should create problems that are both realistic and solvable in multiple ways [28]. Using dynamic graphics in multimedia learning allows students to explore geometric concepts [27]. Multimedia bridges abstract ideas and concrete observations, significantly impacting learning when designed with educational principles and cognitive theories in mind [29]. Computers and digital devices have long helped create visual representations and engage students. Advancing technology allows for integrating multiple representations through various modes, creating more complex visuals [21]. Among available software, GeoGebra is particularly useful for incorporating technology in math education [30]. "GeoGebra can improve problem-solving skills, especially in making logical and creative guesses, by:

- Activating relevant schemas;
- Encouraging the use of problem-solving methods;
- Positively influencing solution process control and individual beliefs [27].

GeoGebra's standout feature is its ability to animate objects and variables, making it an interactive tool for exploring various mathematical outcomes through manipulation. This dynamic software plays a key role in teaching mathematical concepts. GeoGebra, along with programs like Maple and Algebrator, is more than just a math tool; it's designed specifically to improve learning [31]. Different versions of GeoGebra are available for download at www.geogebra.org, compatible with various computer and mobile operating systems.

As a dynamic application, GeoGebra enables students to build and modify geometric and algebraic representations. Its features are designed to improve problem-solving and logical reasoning skills. Students can create mathematical objects based on their questions and hypotheses, deepening their understanding of mathematical concepts [32]. GeoGebra supports multiple languages and offers corresponding online courses, providing comprehensive resources for teachers and students. A dedicated website has been set up to support GeoGebra's practical use [12].

GeoGebra allows teachers to create problems that students can solve using the software, sparking interest and improving understanding of geometric challenges. It encourages active engagement with problem statements and proofs. The software's dynamic nature motivates students to explore mathematics, promoting active participation. As a result, students are more likely to retain knowledge and develop critical thinking and investigative skills. Using GeoGebra's dynamic system helps develop professional competencies for future math educators, especially in information and communication. Examples show that GeoGebra promotes practice-oriented math education and research methods and increases student motivation. The ability to create and study interactive models in GeoGebra's learning environment improves the efficiency of science and math learning, fostering logical thinking and increasing student motivation [33]. Integrating technology in math education allows students to develop diverse and innovative solutions. This approach lets students form and test hypotheses while building mathematical knowledge. Teachers can use GeoGebra to create examples that encourage students to seek answers and spark interest in the subject. This method strengthens students' understanding of geometric problems, enabling them to analyze problem statements and provide logical proofs independently. Previous research examined teaching the chapter on circles and geometric transformations in the Iranian high school Geometry 2 textbook [33]. This study focuses on teaching a different section of the same textbook, specifically longitudinal relationships in triangles (pages 61 to 76). We aim to assess the effectiveness of two teaching methods: using GeoGebra software with practical illustrations, and using researcher-designed examples without software. The study addresses these research questions:

○ To what degree does the integration of GeoGebra software and the inclusion of illustrative examples bolster the comprehension of geometric theorems within the chapter covering longitudinal relationships in triangles found in the Geometry 2 textbook?
○ To what extent does the application of researcher-designed examples, independently created without the assistance of software, facilitate the grasp of geometric theorems in the chapter concerning longitudinal relationships in triangles within the Geometry 2 textbook?

Review of the Related Literature

The learning of mathematics is complex, requiring an understanding of various mathematical concepts [34]. It involves engaging with real-world phenomena through hands-on experiences [34]. Real Mathematics Education became the main approach to mathematics education in the Netherlands starting in 1968 [35]. Between 1987 and 1997, textbooks aligned with Real Mathematics Education grew from 15% to 75% of the market [35]. Recently, the Ministry of Education in Iran formed a commission of teachers to review and update the math curriculum to better prepare students for their personal and professional futures [35]. Research shows that interest and a positive attitude are key to success in mathematics. Oldknow and Taylor [36] note that motivating students through verbal and non-verbal methods is the first step in effective teaching. Students should understand what they're learning and why. One way to boost motivation is by connecting learning materials to students' everyday experiences [37]. A study of 1083 Chinese math teachers found that they often use technology to engage students during lesson planning [38]. Another study of 40 male middle school students in Tehran, Iran, showed that computer games create an engaging environment that improves problem-solving skills, increasing interest in math and leading to better academic performance [39]. A study of 60 high school students in Badrud, Iran, found that using educational simulations significantly improved students' academic goals and overall learning [40]. Geometry often faces challenges related to student attitudes and achievement. Students tend to show less interest and slower progress in geometry compared to other math topics. Geometry is prone to misconceptions and learning difficulties, requiring a deeper understanding for effective learning [41]. Students recognize the importance of teaching methods in their learning process and are aware that different teachers use different approaches. About 60% of students attribute their learning outcomes to their teachers' teaching style [42]. Many studies in educational technology show that students who use technology in learning achieve higher accuracy and proficiency than those who don't [12]. Research by Guven and Kosa [43] highlighted the positive effects of dynamic geometry software on spatial skills. Similarly, GeoGebra, a dynamic math program, has been shown to develop algorithmic thinking skills by visually representing formal and algorithmic aspects of math problems [44]. This technology allows for the creation of complex geometric structures on computer screens [33]. GeoGebra, an open-source dynamic math software program, was developed as part of Markus Hohenwarter's master's thesis at the University of Salzburg, Austria [45]. The goal was to create a program that combined geometry, algebra, and calculus in one user-friendly package, unlike other software that treated these as separate. After its online release in 2002, GeoGebra gained popularity among educators who used it in their classrooms, winning several educational software awards, including the European Academic Software Award in 2002.

Hohenwarter continued improving GeoGebra, inspired by his doctoral research on the software's educational uses in Austrian schools. In 2006, he joined Florida Atlantic University (FAU) as a visiting professor, participating in the National Science Foundation (NSF)-funded Mathematics and Science Partnership (MSP) teacher education initiative [45]. A study in Ankara, Turkey, found that GeoGebra made learning about lines and angles more enjoyable for 7th-grade students [13]. Another study with 24 mathematics education students at Langlangbuana University in Indonesia showed that those using GeoGebra to learn geometric transformations had significantly better math comprehension than those taught traditionally [46]. Recognizing the importance of the mathematics curriculum, future math educators need strong problem-solving skills. A study of 71 second-semester math education students at Tidar University in Indonesia found that learning spatial geometry with GeoGebra improved their problem-solving abilities [47]. Research with student teachers also showed that GeoGebra effectively improved problem-solving skills in analytical geometry courses. Students responded positively to GeoGebra in these courses, showing high interest in multimedia components but less interest in visual imagery [48]. Using concrete, relevant examples is considered effective for learning math [49]. Historically, mathematicians have used examples to form conjectures by creating systematic lists and looking for patterns [50]. A study of 75 middle school math teachers in Markazi Province, Iran, during the 2010-2011 academic year found that while teachers recognized the importance of examples, they lacked knowledge about educational examples and their teaching potential. Their concept of examples did not include theorems, problems, definitions, proofs, or arguments [51].

Trafton and Reiser [52] compared teaching solely through examples with teaching through examples and problem-solving. They found that presenting both examples and problems had a greater impact on learning than examples alone. Students learn best when they can apply knowledge from examples to new problems. The study concluded that the most effective way to structure learning materials is to present a solved example followed by a similar problem for students to solve, allowing them to recognize similarities and support their problem-solving process. In mathematics, introducing real-world problems connects students to the subject and highlights its everyday relevance. This approach creates purposeful experiences that build motivation and curiosity, ultimately improving understanding of mathematical concepts [53]. Research aimed at improving geometry instruction and creating an immersive learning environment suggests that using various techniques, such as incorporating examples and GeoGebra software, can be a significant step forward.

Method

Participants

The study population comprised 332 female 11th-grade students from District 3 of Isfahan during the second half of the 2021-2022 academic year. For the selection of the statistical sample, 60 students from three schools in District 3 of Isfahan were chosen using a purposive sampling method.

The participants were divided into two experimental groups and one control group.

Instruments

All participants completed Cattell's Culture Fair Intelligence Test and a pre-test in Geometry 1 with identical questions. The first experimental group received an instructional video on constructing simple shapes and measuring shape components using GeoGebra software, along with virtual instructions on effective software use. The first author addressed their issues in five one-hour sessions. Additionally, five practical examples related to longitudinal relationships in triangles from the 11th-grade geometry textbook were presented, with responses designed using GeoGebra. Content validity was ensured through feedback from five experienced professors and teachers, who also reviewed aspects such as adherence to Persian grammar. The test questions demonstrated good reliability (Cronbach's alpha = 0.81). Given that this number exceeded 0.7, the test questions demonstrate good reliability.

Design

This research employs a quasi-experimental design with two experimental groups and one control group, including pre-test and post-test assessments. In terms of its objective, it is considered an applied study. Two methods were investigated for teaching longitudinal relationships in Geometry 2: (1) solved examples using GeoGebra software and (2) examples created by the researcher without software. This study tested these hypotheses:

Both methods are more effective for theorem learning than traditional approaches. When teaching geometry theorems, particularly Theorem 2 on longitudinal relationships in triangles, solved examples with GeoGebra have a greater impact than instructional examples alone. Data analysis was conducted using SPSS 25 software, including ANCOVA analysis, Kolmogorov-Smirnov test, and Levene's test.

Procedure

Eleventh-grade math students were divided into three groups: two experimental and one control. The first experimental group used teacher-provided examples and GeoGebra for theorem conjecture and proof. The second group used only teacher-provided examples, while the control group received traditional instruction. The research hypothesis stated: Using examples and GeoGebra software to learn geometric theorems about longitudinal relationships in triangles has a positive effect and is more effective than teaching with examples alone. Figure 4 summarizes the study sessions.

Teaching topics	Sessions
Teaching topic: Determining the length of a triangle's side using one side length and two angles	**Problem (1) Description:** Students were presented with a scenario involving a triangular area in Isfahan city, formed by Khayyam, Motahari, and Saeb streets. Given specific angle measurements and one side length, students were tasked with calculating the length of Khayyam Street.

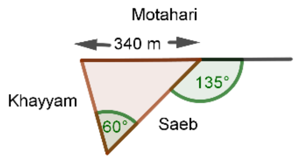


Fig. 1: Figure drawn in GeoGebra for problem 1

Teaching topics	Sessions
Teaching topic: Determining the length of the third side of a triangle using the lengths of two sides and the included angle	**Problem (2) Description:** Students solved a practical problem involving the installation of a slide in a children's playground. They were required to calculate the distance between the base of a ladder and the base of the slide, given specific angle and length constraints.
Teaching topic: Calculating the median length of a triangle using the lengths of its three sides	**Problem (3) Description:** This session involved a real-world application where students calculated the total distance of a route between school, library, sports club, and home, given specific distances between locations.

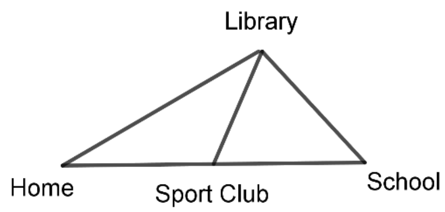


Fig. 2: Figure drawn in Geogebra for problem 3

Teaching topics	Sessions
Teaching topic: Determining the length of the interior angle bisector in a triangle	**Problem (4) Description:** Students engaged with an astronomy-themed problem, calculating the distance between a celestial object and the Sun, using given distances between Earth, Neptune, and the Sun, and the object's position relative to these bodies.

Teaching topic: Calculating the area of a triangle using the lengths of its sides and applying Heron's formula

Problem (5) Description: The final problem involved calculating the total area of a proposed rectangular swimming pool and an adjacent lawn, demonstrating the practical application of area calculations in a real-world context.

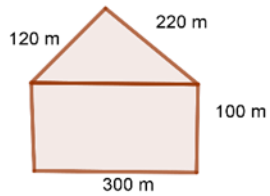


Fig. 3: Figure drawn in Geogebra environment for problem 5

Methodology Note

All problems were presented to students for solving, with figures drawn in the GeoGebra environment to aid visualization and understanding.

Fig. 4: Training sessions overview: Geometry 2 Theorems - Longitudinal triangle relationships.

The questions were based on real-world scenarios. For question 1, Figure 5 shows an aerial image of Motahari, Saeb, and Khayyam streets captured using GPS technology.

Fig. 5: Motahari Street distance (340 meters) - Real image

After receiving the questions, students began solving the problems using tools such as protractors and rulers. They also applied their knowledge of trigonometric relationships, which led to accurate solutions in some cases. For example, in problem 1, students recognized that the sine function could determine the length of the side opposite a given angle in a right triangle. Figure 6 shows a correct solution to question one, as presented by one of the students.

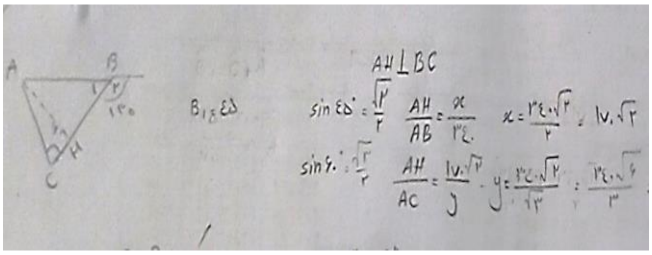


Fig. 6: Problem (1) solution by the experimental group student

In the first experimental group, we enhanced educational examples with GeoGebra software. This allowed for visual representations and measurements, simplifying problem-solving. The dynamic GeoGebra environment lets students test various approaches, shifting between experimental inferences and mathematical reasoning. Students could make initial guesses using the software, observe results, and gather information by exploring different scenarios. This process often led to correct answers through empirical reasoning. While mathematical and experimental approaches seemed equally valuable at first, group discussions and teacher prompts helped students recognize the need for formal proofs to support their ideas. After the groups formulated answers, the teacher provided indirect guidance without intervening in their choices. Solutions were validated through software and group consensus before presentation to the teacher, who then discussed them with students as a peer. If the solution withstood scrutiny, it was presented to the entire class. Group members then defended their assumptions and solutions against critiques from the teacher and other groups, highlighting the importance of formal proof. Initially, some students were hesitant to engage in problem-solving. However, successfully resolving problems led to increased excitement and pride. This enthusiasm grew, encouraging even reluctant students to collaborate actively after the second session. GeoGebra's features, which allowed for quick hypothesis testing while working in groups, further encouraged exploration and research. The process of defending claims and critiquing others' solutions not only increased excitement and problem-solving skills but also improved students' accuracy in presentations and responses. Figure 7 illustrates the solution for problem 1.

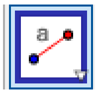
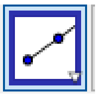
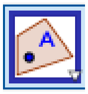
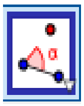
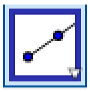
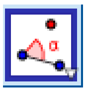
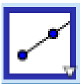
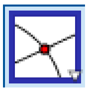
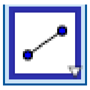
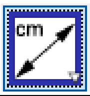
Tool selection	Procedure
	1. Construct a line segment AB with a length of 3.4 units.
	2. From point A, extend a ray passing through line segment AB.
	3. Select an arbitrary point C on the ray extending from A.
	4. At point B, construct an angle of 135° in the clockwise direction from the initial line segment AB.
	5. Extend a ray from point B along the 135° angle constructed in step 4.
	6. At point A, construct an angle of 75° in the clockwise direction from the initial line segment AB.
	7. Extend a ray from point A along the 75° angle constructed in step 6.
	8. Identify the intersection point of the two rays constructed in steps 5 and 7. Label this point D.
	9. Connect points A and D to form line segment AD.
	10. Measure and record the length of line segment AD.

Fig. 7: Problem (1) step-by-step solution using GeoGebra

The final output corresponds to Figure 8.

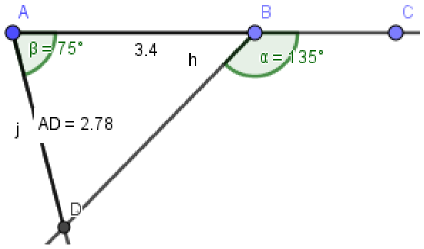


Fig. 8: Problem (1) final solution output in GeoGebra

Using a 1:100 scale applied to the figure, we estimated Khayyam Street's length to be approximately 270 meters. This measurement aligns with the length obtained from the aerial map, as shown in Figure 9.

Fig. 9: Khayyam Street length - Real map measurement

The second experimental group tackled problems using a pen, paper, ruler, and protractor to sketch shapes. Teacher guidance helped them form hypotheses about angle and side relationships, which they then verified. This hands-on approach led to a deeper understanding of theorem proof.

During this time, the control group learned the same content through standard teaching methods. After the course, all groups took a post-test with 20 questions on length relationships in Geometry Triangle 2. To ensure content validity, experienced Geometry 2 teachers evaluated how well the questions measured the content and objectives.

Results and Findings

To test our hypothesis that "Using examples and GeoGebra software for teaching geometric theorems related to longitudinal relationships in triangles has a more positive impact than traditional example-based teaching," we used a one-way analysis of covariance (ANCOVA).

This method allowed us to evaluate the effect of the independent variable on the dependent variable while accounting for potential covariate influences. Before applying ANCOVA, we needed to meet several key conditions:

- Random sampling
- Normal distribution of the dependent variable within each group
- Equal variances of the dependent variable across groups
-. Consistent regression line slope between the covariate and dependent variable at different levels of the independent variable

To assess the initial impact of intelligence on geometry learning, we administered the Kettle Scale 3 intelligence test to both experimental and control groups.

Table 1 shows that the mean intelligence scores of students in both experimental and control groups are similar. We then checked whether students' scores in learning geometry concepts were normally distributed.

The data in Table 2 support the assumption of normal distribution for geometry concept learning scores at the 0.05 significance level. We used Lune's test on these scores to assess the impact of the pre-test on post-test results and to check for equal variances.

Table 3 shows that the F-value for geometry concept learning is not statistically significant ($F = 2.773$, $p > 0.05$). This indicates that the group variances are likely homogeneous. For covariance analysis, we must check if the regression line slope between the covariate and dependent variable is consistent across different levels of the independent variable in both groups. This step is necessary to ensure the covariates are not linked to the independent variables.

Table 4 shows that the independent variable's significance level is 0.234 ($p > 0.05$), indicating it does not significantly affect the dependent variable. The F-values for the interaction between the covariates—pre-test and intelligence (0.080 and 0.560, respectively)—are both above 0.05. This suggests these two variables have little impact on the dependent variable (post-test scores). Therefore, we can conclude that these variables did not significantly influence the post-test scores. The marked improvement in post-test scores appears to be primarily due to the use of examples and GeoGebra software in the experimental groups.

Table 5 reveals several key differences. The average difference between the first experimental group, which used examples and GeoGebra software, and the second experimental group, which used only examples, is 0.975. This difference is significant ($p = 0.022$, < 0.05), showing that the first group performed better than the second. The first experimental group also outperformed the control group, with an average difference of 1.444 ($p = 0.000$). In contrast, the average difference between the second experimental group and the control group is 0.469. This difference is not statistically significant ($p = 0.557$, > 0.05). This suggests that teaching Geometry 2's chapter on longitudinal relationships in triangles using examples alone does not differ significantly from traditional methods.

These findings support the research hypothesis: combining GeoGebra software with examples effectively improves geometry concept understanding among 11th-grade mathematics students.

Table 1: Intelligence scores comparison - Experimental vs. control groups (mean and standard deviation)

	Experiment Group 1		Experiment Group 2		Control Group	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
Intelligence	106.65	11.77	107.05	15.00	106.73	12.66

Table 2: Data normality check - Kolmogorov-Smirnov test

Components	Group	Statistic	D f	Sig.
Learn the Concepts of Geometry	The experiment 1	.129	20	.200
	The experiment 2	.123	20	.200
	Control	.075	20	.200

Table 3: Leven-test to check for equality of variances

Components	F	Df1	Df2	Sig.
Learn the Concepts of Geometry	2.773	2	57	.071

Table 4: Between-subjects effects tests

D f	Source	Mean Square	F	Sig.
2	Group	1.898	1.495	.234
1	Pretest	265.538	209.083	.000
1	Intelligence	1.240	.976	.328
2	Group*Pretest	.102	.080	.923
2	Group* Intelligence	.711	.560	.575

D f	Source	Mean Square	F	Sig.
51	Error	1.270		
60	Total			

Table 5: Pairwise Comparisons

Group(I)	Group(J)	Mean Difference (I-J)	Sig.
Experiment Group 1	Experiment Group 2	.975	.022
	Control Group	1.444	.000
Experiment Group 2	Experiment Group 1	-.975	.022
	Control Group	.469	.557

Discussion

A recent study examined three teaching approaches for the distance relationships chapter in 11th-grade geometry:

- Combining practical, real-world examples designed by the first author with GeoGebra software
- Using these examples independently
- The standard teaching method

Van den Heuvel-Panhuizen and van Zanten [35] argue that students' lack of mathematical understanding often leads to avoidance. They advocate for reality-based mathematics education, which aims to rebuild mathematical concepts using informal knowledge and relatable facts under teacher guidance.Gholam Azad [28] describes this reality-oriented approach as "guided re-creation," where students experience the process of mathematical invention, developing a sense of ownership over their strategies and results. To make geometry more engaging, the first author, an Isfahan resident, drew inspiration from her surroundings. She designed questions to teach geometry theorems related to distance relationships in triangles more effectively. Experienced geometry teachers reviewed these questions. For example, she conceived a problem to estimate the length of Khayyam Street using geometry after crossing the Marnan Bridge near the intersection of Khayyam and Saeb streets. This required knowledge of Motahari Street's length, the distance between Saeb and Khayam streets, and the angles between them. She obtained this information from the "Neshan" route finder program's aerial map. In the geometry class, Question 1 sparked excitement. Some students suggested measuring Khayyam Street in person, viewing it as both an outing and a problem-solving exercise. One student proposed using cycling distance-tracking software. However, the challenge was to solve the problem without leaving the classroom. Geometry provided the solution. The process began with modeling the real-world scenario. Streets were represented as triangle sides, and a graph was drawn using the given angles. Students recalled right-triangle theorems to tackle the problem. In groups using only examples, students worked with pen and paper. But was there a quicker, easier method? Recent years have seen increased student engagement through software use [54]. Research by Mukamba and Makamure [55] shows that integrating information and communication technology, particularly GeoGebra, improves students' understanding of geometric transformations compared to traditional methods. Computer-generated forms and dynamic visuals have improved mathematical concept visualization and representation, outpacing traditional methods in both speed and knowledge retention [54]. Various software applications exist for mathematical problem-solving, including ChatGPT, PhotoMath, Squirrel, Minerva, GeoGebra, and Wolfram Alpha [56].

For geometry problems, GeoGebra stood out as an effective tool for personalizing learning, increasing accessibility, and improving educational assessments [54]. Students, already familiar with GeoGebra from previous lessons, worked in groups of three to model the problem. Using the software's distance calculation feature, they determined the required length. Stronger students assisted those who needed help. The dynamic nature of GeoGebra allowed students to observe how changing angles affected triangle side lengths, encouraging them to hypothesize about side-angle relationships. To conclude, the teacher introduced the sine theorem for triangles. This approach aligns with research by Arbian and Shakur, which confirms GeoGebra's positive impact on student progress [57]. Student participation in problem-solving fostered deeper learning through increased interaction. Shadan and Leong [58] noted that collaborative learning helps students reinforce their knowledge with peer support. Peer interactions enable students to guide each other towards shared understanding. Higher-ability students play a crucial role in helping their lower-ability peers succeed in assignments. This study revealed that GeoGebra software boosts students' motivation to learn geometry. This aligns with Zangin and Tatar's [59] findings that interactive learning environments correlate with cooperative learning in improving student motivation and engagement.

Question 2 was inspired by a real-world scenario: planning a kindergarten next to a school for teachers' children. The challenge was to determine the area needed for a safe, low-height slide. This problem, presented in the second teaching session, introduced the cosine theorem. Notably, some students who previously disliked geometry now looked forward to these classes. However, some viewed the software as a game, requiring careful teacher supervision to maintain educational focus. A student named Maryam, who frequented Horisa Sports Club and planned to visit the Imamzadeh Mohsen (AS) library, inspired Question 3. This problem required calculating a detour route, introducing the concept of midpoint calculations. GeoGebra proved invaluable, offering both speed and accuracy in problem-solving.

Another student, Setayesh, expressed interest in astronomy's geometric applications. This led to Question 4, which incorporated real data about Earth, Neptune, and Sun distances from Google. This problem served to teach the triangle bisector theorem, demonstrating geometry's relevance in astronomical contexts.

The Bakhtiar sports complex, with its swimming pool and green space, inspired Question 5. As the geometry class progressed, student engagement and interest grew, making the subject enjoyable. This outcome aligns with Joshi and Singh's research [60], which found that students view GeoGebra as an effective tool for learning mathematics, grasping concepts, boosting problem-solving confidence, and fostering creativity in a visual, enjoyable manner. However, it's important to note that using GeoGebra effectively requires teachers to have a clear understanding of the shapes they intend to draw. A study of 23 math teachers at a small U.S. university revealed that while they could easily draw familiar shapes, they struggled with less common ones like non-isosceles trapezoids [61]. In the experimental group taught using only designed examples without software, students showed enthusiasm in participation. The use of real-world examples relevant to students' lives increased their motivation to attend and learn geometry. This approach builds on Ozgur's research [24], which highlighted the use of examples for elementary students in exploring, developing, refining, generalizing, and justifying conjectures. The effectiveness of examples in this study aligns with Rezaei and Mohammadzadeh's findings [46]. They identify examples as efficient tools for expressing key features of instructional definitions or explanations in problem-solving. Examples, with their unique characteristics, significantly impact learners' understanding by representing concepts and demonstrating concept formation processes. This research confirmed the hypothesis that combining examples with GeoGebra software for teaching geometric theorems about length relationships in triangles is more effective than using examples alone. This integrated approach encouraged active student engagement, speculation, and a deeper understanding of the subject matter.

Conclusions

This study examined the effectiveness of different methods for teaching distance relationships in triangles. It compared the use of practical examples solved with GeoGebra software against using practical examples alone and traditional teaching methods. For 11th-grade Geometry 2 students, GeoGebra software facilitated more efficient learning of triangle distance relationships without causing frustration. It improved students' software skills while making the geometry classroom more engaging and enjoyable. Introducing practical examples before using GeoGebra for problem-solving enhanced this effect. This approach improved problem-solving skills and increased student motivation for active participation and collaboration. The findings suggest that geometry education should extend beyond theory to include enriching learning tools. Combining GeoGebra software with practical examples in teaching triangle distance relationships empowers students to explore mathematics, develop critical thinking, and unlock their creative potential. Geometry educators are encouraged to learn GeoGebra and effectively incorporate visual aids into their lessons. Recommendations include:

- Encouraging students to install GeoGebra on their personal devices.
- Allocating time for students to become proficient with the software.
- Math teachers designing applied examples for various geometry topics during their planning meetings.
- Having students solve these examples using GeoGebra to experience a more interactive and practical learning approach. This integrated method promotes a more engaging, practical, and effective geometry learning experience.

Authors' Contribution

The first author compiled and analyzed data and wrote the article. The second author (Corresponding author) developed the research concept and design. They also guided the article's compilation and review. The third author provided guidance and advice on drafting and revising the article.

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Conflicts of Interest

The authors declare no conflicts of interest.

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ORIGINAL RESEARCH PAPER

Evaluating the usability of augmented reality for teaching Multiplication to kids

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ABSTRACT

Background and Objectives: The integration of technology in education has significantly transformed the teaching and learning processes. Among the new technologies, augmented reality stands out due to its ability to provide interactive and engaging educational experiences. This technology has been able to improve students' motivation, participation, and understanding of concepts. On the other hand, multiplication, as a fundamental mathematical operation, poses a challenge for students to learn because of its abstract nature. In math subjects, augmented reality has been used to teach geometry and rarely for other areas. Therefore, further exploring the use of this technology in other areas of teaching math, such as algebra, is worth examining. The objective of this research is to explore the usability of augmented reality applications to teach multiplication. Usability is critical to investigate, as it ensures that young users can easily engage with and benefit from educational content. The difficulty of using applications and the lack of attractiveness will negatively impact user engagement. Therefore, examining usability requirements is of great importance.

Materials and Methods: The research method included an expert review and a user survey. A class of 17 third-grade students was selected from a private school, and the researchers implemented instructional plans in collaboration with teachers. The application used was designed by an Iranian group and included multiplication lessons, tests, and educational videos. Its augmented reality capability allowed students to interactively understand multiplication concepts using the phone's camera. The System Usability Scale questionnaire was used with a 5-point Likert scale that was localized for children and translated into Persian to evaluate the usability. This questionnaire included 13 questions about ease of use, interaction, and overall satisfaction with the program. The content validity of the questionnaire was checked using the CVR index, while Cronbach's alpha coefficient was used to check its reliability. The answers were analyzed using SPSS software, and the mean, standard deviation, and correlations were checked.

Findings: This research showed that the augmented reality application for teaching multiplication to children is generally usable and attractive. The questionnaire's validity was confirmed with a CVR score of 0.99, and its reliability was evaluated with Cronbach's alpha of 0.704 at an almost acceptable level. Participants found the program easy to use and engaging, and required little help from adults. Correlation analysis showed that the need for more help was negatively related to decreased confidence in performance, while a better understanding of the program was positively related to willingness to continue working with it.

According to an expert review, the design of the program was compatible with the cognitive needs of children and uses simple design, bright colors, and attractive characters; However, the use of a small font and the lack of in-app audio and visual guides were among its weaknesses. Physically, the app had large buttons, well-spaced components, and simple menus that made it easy to work with. In terms of social-emotional needs, it was possible to choose a male or female narrator and use the augmented reality feature, but there were no customization options such as changing the background or characters, and gamification elements such as scoring or creating a sense of progress.

Conclusions: Incorporating augmented reality applications into math education can increase student engagement and motivation, but considerable attention to usability guidelines and improvements in app design are necessary. This research, in addition to highlighting the

principles that are necessary in the design of the user interface of the augmented reality program for teaching multiplication, to make it attractive and easy to use for children, has taken an innovative step in the evaluation of educational programs by presenting the Persian version of the System Usability Scale questionnaire for children, using a systematic approach to translate and localize the questionnaire.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
35	4	4

مقاله پژوهشی

ارزیابی کاربردپذیری واقعیت افزوده برای آموزش ضرب به کودکان

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۰۲۱- ۱۲۳۴۵۶

پیشینه و اهداف: ادغام فناوری در آموزش، فرآیندهای آموزش و یادگیری را به طور قابل توجهی متحول کرده است. در میان فناوری‌های جدید، واقعیت افزوده به دلیل توانایی آن در ارائه تجربیات آموزشی تعاملی و جذاب برجسته است. این فناوری توانسته انگیزه، مشارکت و درک مفاهیم را در دانش آموزان بهبود بخشد. از سویی دانش‌آموزان برای یادگیری ضرب، به عنوان یک عملیات ریاضی اساسی، به دلیل ماهیت انتزاعی آن، با چالش مواجه هستند. در دروس ریاضی، واقعیت افزوده معمولاً برای آموزش هندسه و به ندرت برای سایر زمینه‌ها استفاده می‌شود. بنابراین، بررسی بیشتر استفاده از این فناوری در زمینه‌های دیگری آموزش ریاضی مانند جبر حائز اهمیت است. هدف این تحقیق بررسی قابلیت استفاده برنامه‌های کاربردی واقعیت افزوده برای آموزش ضرب است. قابلیت استفاده یا کاربردپذیری از اهمیت بالایی برخوردار است، زیرا اطمینان می‌دهد که کاربران به‌راحتی می‌توانند با محتوای آموزشی تعامل داشته و از آن بهره‌مند شوند. سختی استفاده از برنامه‌های کاربردی و جذاب نبودن آنها تاثیر منفی بر میزان بهره برداری کاربران خواهد داشت و بنابراین بررسی ملزومات کاربردپذیری از اهمیت بسیاری برخوردار است.

روش‌ها: روش این تحقیق شامل بررسی تخصصی و نظرسنجی از کاربران است. یک کلاس متشکل از ۱۷ دانش آموز کلاس سوم از یک مدرسه خصوصی انتخاب شدند و محققان طرح‌های آموزشی را با همکاری معلمان اجرا کردند. برنامه کاربردی مورد استفاده توسط یک گروه ایرانی طراحی شده و شامل درس ضرب، تست و فیلم آموزشی می‌باشد. قابلیت واقعیت افزوده این برنامه به دانش‌آموزان اجازه می‌دهد تا مفاهیم ضرب را با استفاده از دوربین گوشی به طور تعاملی درک کنند. برای ارزیابی کاربردپذیری این برنامه پرسشنامه مقیاس کاربردپذیری سیستم با مقیاس ۵ گزینه‌ای لیکرت که برای کودکان بومی سازی و به فارسی ترجمه شد، استفاده شده است. این پرسشنامه شامل ۱۳ سوال در مورد سهولت استفاده، تعامل و رضایت کلی از برنامه بود. روایی محتوایی پرسشنامه با استفاده از شاخص CVR و پایایی آن به کمک آلفای کرونباخ بررسی شد. پاسخ ها با استفاده از نرم افزار SPSS مورد تجزیه و تحلیل قرار گرفت و میانگین، انحراف معیار و همبستگی‌ها بررسی شد.

یافته‌ها: نتایج این تحقیق نشان داد که کاربرد واقعیت افزوده برای آموزش ضرب به کودکان به طور کلی قابل استفاده و جذاب است. روایی پرسشنامه مورد استفاده با نمره CVR برابر با ۰/۹۹تأیید شد و پایایی آن با آلفای کرونباخ ۰/۷۰۴ در سطح تقریباً قابل قبولی ارزیابی شد. شرکت‌کنندگان این برنامه را برای استفاده آسان و جذاب یافتند و نیاز به کمک

زیادی از طرف بزرگسالان برای کار با برنامه نداشتند. تجزیه و تحلیل همبستگی نشان داد که نیاز به کمک بیشتر با کاهش اعتماد به عملکرد رابطه منفی دارد، در حالی که درک بهتر برنامه به طور مثبت با تمایل به ادامه کار با آن مرتبط است.

نتیجه بررسی خبرگان نشان داد که طراحی این برنامه با نیازهای شناختی کودکان سازگار بوده و از طراحی ساده، رنگ‌های روشن و شخصیت‌های جذاب استفاده شده است. اما استفاده از فونت کوچک و نبود راهنمای صوتی و تصویری درون برنامه از نقاط ضعف آن بود. از نظر فیزیکی، برنامه دارای دکمه‌های بزرگ، اجزای با فاصله مناسب و منوهای ساده بود که کار با آن را آسان می‌کرد. از نظر نیازهای عاطفی اجتماعی، امکان انتخاب راوی مرد یا زن و استفاده از ویژگی واقعیت افزوده وجود داشت، اما هیچ گزینه سفارشی‌سازی مانند تغییر پس‌زمینه یا شخصیت‌ها و عناصر گیمیفیکیشن مانند امتیاز دادن یا ایجاد حس پیشرفت وجود نداشت.

نتیجه‌گیری: گنجاندن برنامه‌های واقعیت افزوده در آموزش ریاضی می‌تولند تعامل و انگیزه دانش‌آموزان را افزایش دهد، اما توجه به دستورالعمل‌های کاربردپذیری و بهبود در طراحی برنامه‌های کاربردی ضروری است. این پژوهش علاوه بر برجسته کردن اصولی که در طراحی رابط کاربری برنامه واقعیت افزوده برای آموزش ضرب لازم است رعایت شود تا استفاده از آن را برای کودکان جذاب و آسان نماید، با ارائه نسخه فارسی پرسشنامه مقیاس کاربردپذیری سیستم برای کودکان و با رویکردی نظام‌مند برای ترجمه و بومی‌سازی پرسشنامه گامی نوآورانه در ارزیابی برنامه‌های کاربردی آموزشی برداشته است.

Introduction

Instructional design plays an important role in the development of learning tools, and the integration of modern technologies such as augmented reality requires the use of instructional design principles to enhance effectiveness and engage learners. Learning theories such as constructivism, active learning, and game-based learning can contribute to improving the process of teaching mathematics.

Mobile Augmented Reality (AR) apps are becoming revolutionary tools in education, offering fun and engaging ways to help students learn. With smartphones and AR technology becoming more accessible, researchers explore how these tools can create interactive and immersive learning experiences. One area where AR can make a difference is teaching young kids fundamental math concepts, like multiplication. By blending digital visuals with the real world, AR helps bring abstract ideas to life, turning traditional lessons into exciting, hands-on learning adventures. AR can be used to enhance Mathematics perception, which is essential for developing effective educational strategies [1].

Teaching multiplication can sometimes feel like an uphill battle. Kids need to grasp number relationships and memorize times tables, which isn't always easy. Traditional methods might not hold their interest for long, leading to frustration or disengagement. That's where mobile AR apps come in, offering a fresh approach. By using interactive visuals, real-time feedback, and even gamifying the learning process, these apps make learning multiplication more exciting and accessible. Kids can visualize and interact with numbers in a way that makes the material easier to understand and remember.

While the potential benefits of AR in education are substantial, some challenges exist that need to be addressed for successful implementation. These challenges include the need for teacher training, the integration of AR into existing curricula, and technological barriers. [2, 3]. Further, it is important to design and develop user-friendly applications. Usability in educational applications plays a fundamental role in engaging students and enhancing user interaction. A simple, fluent, attractive user interface helps students access academic content and understand concepts better without feeling confused or tired. If the application is complex and difficult to understand, users will quickly lose interest, and learning will be hindered. Therefore, user-friendly design implementing the principles of user experience (UX) and usability can increase user involvement and make learning an enjoyable and effective experience.

To make AR apps truly effective for kids, they need to be designed with kids in mind. Evaluating how usable these apps are is a key part of ensuring they hit the mark. Usability testing looks at how simple and enjoyable an app is for children, considering things like how easy it is to navigate, how well the design fits their needs, and how responsive it is. Since kids' abilities and preferences differ from adults, it's crucial to think about their unique needs. An app's success depends on how intuitive it is, whether the content is appropriate for their age, and how well it keeps them engaged.

Beyond usability, it's also essential to see if the AR app truly helps with learning. The best educational AR apps are not just easy to use, but they also encourage active participation, problem-solving, and practice. By evaluating both how user-friendly and effective the app is at teaching multiplication, developers and educators can ensure these tools are not only fun but also help kids succeed in their learning journey. However, the focus of this study is just on the usability of the AR app for teaching multiplication to children. This research aims to evaluate the users' and experts' feedback regarding augmented reality software for teaching multiplication, to examine aspects of how such software should be designed.

The contribution of this research, besides exploring the usability of AR applications to teach multiplication, is providing a Persian version of the System Usability Scale questionnaire for kids. The SUS is designed for adults in its standard mode, but for children, it needs to be simplified and localized to suit their cognitive and language abilities. Preparing the SUS questionnaire for children is especially important because this tool is used to evaluate the usability of products, systems, and software designed specifically for kids. This research uses the SUS questionnaire adapted for kids. [4] and follows a systematic approach [5] To translate the kids' SUS questionnaire into Persian, which has not been done before.

Review of the Related Literature

Each emerging technology comes with opportunities and challenges for use, particularly in education and learning. One such technology is augmented reality, which, with its capability to run on mobile phones, has shifted from purely a research topic to a practical application. Augmented reality software enables students to visually understand concepts and interact with virtual elements from various angles, sometimes even allowing them to design objects.

The advantages of using augmented reality for students include increased motivation, attention, interaction, satisfaction, and focus. As a result, the student's interest in the subject grows, leading to a better learning experience and faster progress. One of the benefits of augmented reality is the ability to receive additional information simultaneously, which allows students to view content practically and from different perspectives, thereby increasing their motivation to learn and strive further [6].

Since learning is not always possible through a single approach, methods such as games and simulations that serve specific educational purposes can be not only enjoyable but also enhance learners' engagement, depth, and retention [7]. Using innovative and creative methods can positively impact students' interest in learning and promote cohesion and retention in learning [8]. Augmented reality applications, with their unique features, can provide significant assistance in this regard [6].

Another important aspect of using AR technology is educating individuals with learning disabilities or special needs. Augmented reality capabilities, such as adding sound to concepts for those with visual impairments or adding text to describe images for those with hearing difficulties, can help reduce these individuals' learning limitations. It can even aid those with physical limitations in their hands and feet [9].

Currently, AR technology has become very popular in education, especially in mathematics, and its use has facilitated the teaching and learning of mathematics [10]. In teaching and learning mathematics, augmented reality technology offers significant advantages. A study conducted by Rohendi and Wihardi [11] among secondary school students in Indonesia showed that the use of AR increased spatial learning activities in geometry. Using AR can also help students better understand concepts related to 3D shapes. In another study conducted in Türkiye, researchers found that the mobile-supported learning environment in the field of algebra has a positive effect on the academic achievement and motivation of secondary school students [12].

The effect of using AR in math education is classified into two cognitive and affective domains. In terms of cognitive influence, it enhances conceptual knowledge [12-15], procedural knowledge [12, 13, 15], and academic achievement [12, 14]. These results show that AR technology had the greatest impact on students' conceptual understanding. In terms of Affective impact, students' attitudes [15, 16] and motivation [12, 14] are influenced.

Ivan and Matt conducted research where AR technology has been used in three main math subjects in secondary education, including geometry, algebra, and statistics & probability [17]. Their findings show that AR has been used more in geometry due to its 3D visualization capability. Since one of the core components of the school mathematics curriculum is algebra, it is vital to investigate further how new technologies such as AR can enhance algebra teaching and learning. Some view algebraic thinking in mathematics as a gateway to higher education and greater opportunities for successful participation in society and the technology market.

As basics for algebra, in elementary mathematics, the most important relationships to be emphasized involve the connections between arithmetic concepts, such as the relationships between numbers, the connections between numbers and the four basic operations, and the interrelations of these operations [18]. Some of the relationships presented in third-grade math textbooks include multiples of a number, patterns in the multiplication table, the relationship between multiplication and addition, and the relationship between multiplication and division. So, multiplication is one of the important topics of third-grade mathematics.

Teaching and memorizing the multiplication table is crucial for understanding and applying these relationships. Teaching multiplication poses a challenge for third-grade students, teachers, and even parents, as it requires integrating with students' memory and is more complex than addition and subtraction [19]. In traditional mathematics instruction, emphasis is mostly placed on repetition and practice. This approach does not account for students' differences, talents, or interests. Therefore, suitable methods must be devised, and multisensory techniques should be employed to ease the learning process. AR technology can help in this regard [6].

Rebollo and her colleagues [6] researched the design and evaluation of an AR game to learn multiplication. The purpose of the research was to implement a more attractive method to practice multiplication using two mini-games, one with the genre of turn-based combat and the other with the genre of throwing objects. To make it more interesting, the games used augmented reality technology, which enables the display of game images and scenes in the users' real environment, thus improving the learning experience. In this study, a test was conducted with the participation of 8-9-year-old children. They were divided into two experimental and control groups; The experimental group used the augmented reality game to practice the multiplication table, and the control group traditionally used the exercise book. Children in the experimental group interacted more with the activity and showed more enthusiasm than the traditional method. In this study, a researcher-made questionnaire containing 13 questions with a 5-point Likert scale, which investigated the satisfaction and ease of using the program, was used. Evaluations indicated the game's user-friendliness and ease of use on smartphones, although some children felt bored at times. The authors suggested improvements in augmented reality interaction and social game development as future work.

In another study Volioti et al. [20], an augmented reality program designed to enhance math learning for sixth graders through real-world problems like recipes. The program was evaluated using the System Usability Scale (SUS) and interviews with three groups: philosophy and education students, engineering students, and elementary students. Philosophy and education students rated usability highest (SUS 76.31), emphasizing its educational value and engagement benefits. Engineering students gave a lower score (65.24), citing interface issues and suggesting improvements like a help button and clearer instructions. Elementary students rated it 68.43, finding it engaging but somewhat difficult to navigate. The overall SUS score of 70.01 indicated acceptable usability, though refinements could improve intuitiveness, especially for younger users.

Hadadi evaluated the applicability of the GeoGebra educational software, which is used as a dynamic geometry tool for teaching mathematics in Australian schools. The research aimed to identify the challenges and usability issues of this software for students and teachers so that by improving the user interface, learning mathematics through the software can be optimized [21]. In this regard, the System Usability Scale (SUS) questionnaire was used to evaluate the opinions of students and teachers regarding the ease of use and attractiveness of the GeoGebra user interface, as well as the problems that novice users may encounter. In addition to the questionnaire, researchers have analyzed the qualitative responses of users. The results show that despite the positive effect of GeoGebra in improving educational achievements, some users have felt uncomfortable with the complexities of the software's user interface. The researcher recommended reducing the complexity and memory load of users, coordinating the system with the real world, minimalist and aesthetic design, prevention of errors, and support and documentation to increase the effectiveness and applicability of educational software so that learning takes place more effectively and attractively.

To make AR applications more effective, applying usability guidelines and designing apps that are user-friendly is essential. The design aspects of using technology and specifically AR applications in education to help further learning impacts are vital. Generally, researches focus on the learning effects of using AR in education, and the usability aspects of these apps are rarely investigated.

Further, to develop applications for kids it is vital to address their specific needs since children's preferences are significantly different from adults. As for adults, usability evaluation of apps for kids is important. Usability focuses on easy and enjoyable use of the system and is dependent on easy navigation, responsiveness, and suitable design which significantly affects kids using educational apps. Therefore, due to the importance of making learning math, and particularly multiplication, easier and more enjoyable for kids, this research introduces an Iranian AR application in this field and explores its usability to highlight the design requirements of such applications. AR applications are mostly investigated in geometry teaching [17] and rarely are used in teaching algebra and specifically multiplication. Therefore, the current research is novel in this aspect too.

By focusing on usability aspects, this research provides valuable insights into the design requirements of AR applications tailored for young learners. The findings will contribute to the development of more intuitive and engaging AR-based learning tools, ensuring that they are not only educational but also enjoyable and accessible to children.

Method

The present study aims to examine the usability of educational software, with an emphasis on augmented reality, to teach multiplication to third-grade elementary school students. In terms of its objective, it is applied research, as it seeks to develop practical knowledge in a specific field.

Participants

A third-grade class consisting of 17 students, from a private school was selected.

Instruments

The method is a combination of expert review and user survey. Researchers from the usability and human-computer interaction field worked with the application and analyzed its usability, considering usability guidelines [22, 23]. Further, to study the feedback of users, participants were selected by a purposive sampling method.

To evaluate the usability of products, services, and systems, various methods exist. One of the most common tools for assessing usability is the SUS questionnaire, introduced by Brooke in 1996 [24]. This questionnaire was initially developed as a tool to measure the subjective usability of industrial systems.

The SUS questionnaire has been used for many years across different fields and structures, demonstrating high efficiency. Additionally, due to its speed and ease of usability measurement, it has attracted significant attention from researchers [25]. Bangor and colleagues, after ten years of studying this questionnaire, concluded that SUS is a highly robust tool with diverse applications [26]. In a comparison between the SUS questionnaire by Brooke and a newer questionnaire introduced in 2009 by Lewis and Sauro, it was shown that the SUS questionnaire is much more suitable for accurately evaluating usability [27].

Therefore, in the last session, the SUS (System Usability Scale) questionnaire with a 5 Likert scale was distributed to the students, the researcher explained its questions to them, and asked them to provide their responses. The SUS questionnaire used in this research is the one adapted for kids [4]. This questionnaire consisted of 13 questions designed to evaluate different aspects of the program, such as ease of use, interaction, and overall satisfaction. Based on Putnam and her colleagues' recommendation, the symbols shown in Fig. 1 were used for answers.

Fig. 1: Symbols for the questionnaire answers [4]

Since this study was conducted in Persian, the questionnaire was translated into Farsi. As the first step to perform the linguistic validation, the main questionnaire was translated into Farsi, using the standard method of backward-forward [5]. Therefore, questions were first translated into Farsi independently by two language experts. Then, two other independent translators did a reverse translation. Finally, to ensure that both English versions are equivalent to each other and have the same meaning, they were compared with the original version, and after choosing a semantic equivalent and a suitable term for words to adapt the questionnaire with multiplication application, the final version of the translation was prepared.

Evaluation of Face Validity of the Questionnaire

Face validity is an objective judgment regarding the structure of the instrument and addresses the following questions:

- Do the individuals who are supposed to respond to the questions agree with the wording and phrasing of the instrument?
- Does the interpretation of non-expert respondents (the target group) align with the researcher's intended meaning?
- Are the overall structure and components of the instrument acceptable to the respondents? [28]

To determine the face validity of the questionnaire, it was reviewed by 5 university professors specializing in education, educational technology, and information technology. They were asked to evaluate the difficulty level, inconsistency, ambiguity of statements, and potential deficiencies in word meanings. Based on their feedback, minor modifications were made to the questionnaire to enhance its clarity and appropriateness.

Content Validity Assessment of the Questionnaire and AR Content

Content validity addresses the following questions:

- Does the designed instrument cover all essential aspects of the intended concept?
- Do the constructs of the instrument measure what they are supposed to assess?
- Are the overall structure and components acceptable to relevant experts? [28]

The content validity of the questionnaire was evaluated using the Content Validity Ratio (CVR) and the Content Validity Index (CVI). The Average Content Validity Index (S-CVI/Ave) was also calculated.

In this study, the CVR was evaluated, using education (1), which is presented by Lavshi [29]. Both the questionnaire and the AR content of the program were given to 5 experts and asked them to express their opinion precisely about each question of the questionnaire in three judgment scales: "necessary", "useful but unnecessary", and "unnecessary". Further, they were asked to assess the alignment of the AR content with the educational objectives of the multiplication table. In Lawshi's suggested method, the minimum number of respondents is 4. In the CVR equation, n is the total number of people who answered, and n_e is the number of people who found the questions necessary.

$$\mathrm{CVR} = (\mathrm{n_e} - \tfrac{\mathrm{n}}{2})/(\tfrac{\mathrm{n}}{2}) \quad (1)$$

The CVI was calculated based on the Waltz and Basel method [30]. According to Ayre and Scally, a CVI score of 0.79 or higher is recommended for item acceptance. If the CVI score is between 0.70 and 0.79, the item requires revision and refinement. Items with a CVI score below 0.70 should be eliminated [31]. In this method, experts are asked to evaluate the level of relevance, simplicity, and clarity of each question on a 4 Likert scale. The CVI was calculated using the Waltz and Bausell formula. For each question, the average of simplicity CVI, relevance CVI, and clarity CVI is calculated.

The average content validity index (S-CVI/Ave) for the questionnaire was calculated based on the mean CVI scores of all items. According to Polit and Beck, a score of 0.90 or higher is recommended for acceptance [32]. The CVI score for each item was determined by dividing the number of experts who rated the item as 3 or 4 (highest scores) by the total number of experts. This method ensures that only the most relevant, clear, and simple items are retained in the final questionnaire.

The reliability of the questionnaire was assessed by calculating Cronbach's alpha, which was 0.704. To assess the reliability of the AR content, the test-retest reliability method [33] was used. Students interacted with the program again after two weeks, and the results were compared. The obtained Cronbach's Alpha value was 0.78, indicating an acceptable level of educational content reliability.

To analyze the results of the questionnaire using SPSS software, Mean, Standard deviation, and Pearson correlation were calculated. A Pearson correlation analysis was also conducted to examine the relationship between the level of assistance needed in using the app, trust in its performance, and the willingness to continue using the app.

Procedure

Before conducting the study with students, one of the researchers, coordinated with the relevant authorities to implement the research at the school. Then teaching methods were explained to the teacher, the educational application was introduced, and a copy was provided to the teacher for familiarization, working with the environment, and installation. Given the number of students, four programs were prepared by the researcher and installed on four mobile phones.

The augmented reality multiplication application that was used in this study is based on a marker and was developed by an Iranian programming group called Persia. The related app can be downloaded and installed through the corresponding website (https://parsia-app.ir/2023/06/26/zarb/). This program includes a page where entering a code activates the program. The program environment features multiplication tutorials, categorization, tests with two difficulty levels (easy and difficult), educational videos for the concept of multiplication, multiplication rules, multiplying a two-digit number by a one-digit number, multiplying a two-digit number by a two-digit number, multiplying fractional numbers, and multiplying decimal numbers. The AR content included 3D animations, dynamic numerical displays, touch interaction, and visual simulations of mathematical problems, all of which were tailored according to interaction design principles for digital learning environments.

Since the application used in this research is not developed by researchers, this study did not aim to examine the technical standards of software design and development, but focused on evaluating the software's performance in the educational environment, assessing student interaction levels, and analyzing its usability from the perspectives of users and educational experts.

However, the preliminary review revealed that the software follows some common technical standards in augmented reality development, including:

- Use of ARCore/ARKit: Support for standard augmented reality technologies for processing and displaying 3D content.
- Adequate graphical clarity: The 3D models are optimized and comply with Low-Poly Rendering design standards for mobile execution.

However, a detailed examination of the software's code and the implementation of technical standards is beyond the scope of this study.

Design

To use the augmented reality (AR) feature of this program, it can be activated at the top right corner of the screen. The mobile phone camera is turned on, and by scanning the screen, the program environment appears on the device (Fig. 2).

Fig. 2: Photos of the application

The design of educational activities in this study was based on Gagné's Nine Events of Instruction [34], which include stages such as gaining attention, presenting stimuli, providing learning guidance, practice, feedback, and performance assessment. In the augmented reality multiplication sessions, students' interaction with the content increased, and learning was facilitated through visual and interactive activities.

The lesson plans for 6 sessions, each 45 minutes, were written by the researcher with the guidance of the teacher. The general objective of session one was to familiarize students with multiplication. Students listened to the instructor's explanation and a video, then shared their understanding in groups. Using an AR multiplication app, they explored multiplication concepts by activating the AR feature and watching educational videos. After summarizing their learning, they practiced the first and second rows of the multiplication table by entering numbers into the app (e.g., 1×1 to 1×9, then 2×1 to 2×9) and observing visual examples (Fig. 3). Finally, they completed exercises in the textbook.

Fig. 3: A part of the implementation steps in the first session

The same process was conducted in the second session. After discussing and talking about drawing the axis and shapes for multiplication, students started working with numbers (teaching multiplication of 3 and 4). For this session, students should set the number in the square to 3 and the number in the circle to 1 through 9, one at a time, observing the changes. Then, they repeated this process for the number 4 (Fig. 4.)

Fig. 4: A part of the implementation steps in the second session

The other 3 sessions were assigned to learning multiplying to 5 and 6, 7 and 8, 9 respectively. In the final session, multiplication exercises at a difficult level were addressed. Six questions on the fundamentals of multiplication and the multiplication table from the third-grade elementary school textbook were designed and asked students to solve them using the application.

Results and Findings

To assess the validity of the SUS questionnaire used in this research, the CVR score was calculated, which was 1. Considering the number of respondents and referring to Lavshi's table for 5 members [29], the minimum score of 0.99 is accepted, which is the one gained in this research (Table 1). Further, all 5 experts believed that the AR content aligned with the educational objectives of the multiplication table. The experts confirmed that the educational content designed in the augmented reality environment demonstrated appropriate validity in terms of conceptual accuracy, alignment with educational principles, and compatibility with the mathematics curriculum.

According to Waltz and Bausell's method, the minimum acceptable CVI value for each question must be 0.79. The results showed that the Content Validity Index (CVI) for all questionnaire items (Table 2) met the acceptable threshold of 0.79. Finally, the Average Content Validity Index (S-CVI/Ave) was calculated, resulting in a value of 0.928, which falls within the acceptable range.

The Cronbach's alpha of the questionnaire was 0.704, which shows nearly acceptable reliability.

Even though all respondents had never used AR for learning math, they reported that The application was easy to use and understand (4.56 mean score for Q3: I think the application was easy to use). The SUS questionnaire used in this research includes positive questions, which are odd-numbered ones, plus Q12, and negative ones for even-numbered. Table 3 shows the SUS questionnaire analysis, including mean values.

Results show that the participants were very interested in using the multiplication app (Q1 (4.65)) and thought the program was easy to use (Q3 (4.65)). They found the application enjoyable (Q11 (4.41)) and tended to spend more time working with it (Q12 (4.35)). Questions with low averages indicate that working with the program was not so difficult and there was little need to do strange things to use it or ask adults for help (Q2 (1.41), Q8 (1.76), and Q4 (2.12)).

A low standard deviation in Q1, Q2, and Q3 indicates that most respondents agree on the ease of using the application. However, the high standard deviation in Q4 and Q10 shows that students had various perceptions of the learnability of the program.

To investigate if there is any correlation between questions, Pearson correlation was calculated, and where it was significant is demonstrated in Table 4.

Table 1: CVR Results and Acceptance/Rejection of Questions of the SUS questionnaire for kids

	Question	CVR	Accept/Reject
1	I think if I had the multiplication app on my phone, I would love to work with it a lot.	1	Accept
2	I often got confused when working with the multiplication program.	1	Accept
3	I think it was easy to use the multiplication program.	1	Accept
4	I think I need help from older people to work with the multiplication program.	1	Accept
5	When I was working with the multiplication program, I knew what to do next.	1	Accept
6	Some of the things I had to do while working with the multiplication program were incomprehensible	1	Accept
7	I think most of my friends can learn to work with the multiplication program very quickly.	1	Accept
8	Some of the things I had to do to work with the multiplication program were strange	1	Accept
9	I felt confident when I worked with the multiplication program	1	Accept
10	I had to learn a lot before I worked with the multiplication program	1	Accept
11	I really enjoyed working with the multiplication program	1	Accept
12	If I had more time, I would continue working with the multiplication program	1	Accept
13	I plan to talk to my friends about the multiplication program.	1	Accept

Table 2: CVI of the SUS questionnaire for kids

	Question	CVI	Accept/Reject
1	I think if I had the multiplication app on my phone, I would love to work with it a lot.	0.87	Accept
2	I often got confused when working with the multiplication program.	1	Accept
3	I think it was easy to use the multiplication program.	0.93	Accept
4	I think I need help from older people to work with the multiplication program.	1	Accept
5	When I was working with the multiplication program, I knew what to do next.	0.87	Accept
6	Some of the things I had to do while working with the multiplication program were incomprehensible	0.93	Accept
7	I think most of my friends can learn to work with the multiplication program very quickly.	0.93	Accept
8	Some of the things I had to do to work with the multiplication program were strange	0.8	Accept
9	I felt confident when I worked with the multiplication program	1	Accept
10	I had to learn a lot before I worked with the multiplication program	0.87	Accept
11	I really enjoyed working with the multiplication program	1	Accept
12	If I had more time, I would continue working with the multiplication program	1	Accept
13	I plan to talk to my friends about the multiplication program.	0.87	Accept

Table 3: Response to the SUS questionnaire

Question	Question	Mean score	Sd
Q1	I think if I had the multiplication app on my phone, I would love to work with it a lot.	4.65	0.61
Q2	I often got confused when working with the multiplication program.	1.41	0.71
Q3	I think it was easy to use the multiplication program.	4.65	0.86
Q4	I think I need help from older people to work with the multiplication program.	2.12	1.58
Q5	When I was working with the multiplication program, I knew what to do next.	4.24	1.39
Q6	Some of the things I had to do while working with the multiplication program were incomprehensible	1.94	1.43
Q7	I think most of my friends can learn to work with the multiplication program very quickly.	4.06	1.03
Q8	Some of the things I had to do to work with the multiplication program were strange	1.76	1.35
Q9	I felt confident when I worked with the multiplication program	4	1.66
Q10	I had to learn a lot before I worked with the multiplication program	3.06	1.75
Q11	I really enjoyed working with the multiplication program	4.41	1.12
Q12	If I had more time, I would continue working with the multiplication program	4.25	1.00
Q13	I plan to talk to my friends about the multiplication program.	3.29	1.72

Table 4. Pearson correlation results

Questions	Pearson Correlation Coefficient (r)	p-value	Correlation Type
Q4 and Q5	-0.668	0.003	Negative Significant
Q6 and Q8	0.574	0.016	Positive Significant
Q10 and Q12	0.705	0.002	Positive Significant
Q4 and Q13	-0.566	0.018	Negative Significant

Results demonstrate a negative correlation between Q4 and Q5 (-0.668 with sig=.003), meaning that Individuals who feel that they need assistance in using the app may feel less comfortable using it, and as a result, may require more guidance and direction to predict their next steps. This negative correlation could indicate that trust in the app's performance and the ability to use it independently have an inverse relationship.

Q6 and Q8 (0.574 with sig=0.016) are positively correlated, indicating that issues in understanding the app's functions could be associated with a sense of incompatibility or the unusual nature of some of its tasks and features. In general, a negative experience with the user interface or the app's complexities could lead to feelings of confusion or strangeness regarding the tasks.

A positive correlation is also observed between Q10 and Q12 (0.705 with sig=00.2), which can be interpreted as even if students feel that they need to learn more, they are still interested in continuing to use the app and are willing to spend more time mastering it.

Further, Q4 and Q13 (−0.566 with sig=0.018) are negatively correlated, suggesting that as the need for assistance in using the app increases, there is less willingness to talk to friends about the app. In other words, individuals who require more help may be less inclined to discuss and share their experiences with others.

The result of the expert review is as follows: in terms of cognitive requirements, the application uses simple designs, bright colors, and attractive characters for children. Fonts are mostly readable; however, instructions are in a small font, which is not suitable for children. Complex and heavy texts are not used. Audio and visual guidance are not provided for children except for multiple small font sentences. Finally, it provides immediate and positive feedback to confirm children's correct or incorrect answers. Further, it lets children do the test without penalty.

In terms of physical requirements, buttons are large enough that children can click them without making a mistake, and they are placed at a suitable distance from each other to avoid the wrong touch. Only simple gestures, such as tapping, are required. No complicated menu is designed in this application. The child can easily return to the main page or choose the next activity.

In terms of Socio-Emotional requirements, children can select a man or woman narrator and choose to use AR or not; however, no other personalization option, such as changing background or characters, is provided. Two levels of hardship are selectable. This app contains no advertisements or external links that can confuse children. Gamification elements such as scoring, stars, coins, or unlocking new levels are not used. The game doesn’t give the child a sense of progress and success. Children can’t have personal profiles in this application.

From an instructional design perspective, the augmented reality-based multiplication program had strengths such as the use of engaging visual images, interactive exercises, and the provision of instant feedback. However, experts suggested that to enhance educational effectiveness, approaches like multisensory learning, adaptive learning tailored to students' levels, and gamification could be utilized.

Discussion

The results of this study indicate that the AR-based multiplication app was generally well-received by third-grade students, showing positive usability and engagement outcomes. High mean scores for statements like "I think using the app was easy" (Q3, 4.65) and "I enjoyed working with the app" (Q11, 4.41) demonstrate that the application succeeded in delivering an enjoyable and intuitive learning experience. These findings are in line with previous studies, such as Rebollo [6] and his colleagues showed that augmented reality programs can make the learning experience more interactive and engaging and increase student engagement. Additionally, students stated a strong inclination to continue using the app, as reflected in Q12 (4.25). This suggests that integrating interactive AR tools into the classroom can enhance motivation and engagement in learning fundamental math concepts like multiplication.

On the other hand, the responses to Q2 (1.41) and Q8 (1.76) indicate that students rarely found the app confusing or required performing strange actions to operate it. Likewise, a low mean score for Q4 (2.12) expresses that most students did not feel adult assistance was necessary, reflecting the app's ease of navigation. However, the higher standard deviation for Q4 and Q10 suggests variability in individual learning needs, where some students found the app more challenging, requiring additional guidance or prior knowledge. This is in line with the expert review that downgrades the level of learnability of the application since it does not provide in-app audio and visual guidance for children. The need for help facilities in applications is emphasized in other studies, too [20, 21].

Overall, the findings suggest that the AR-based app effectively combines usability, enjoyment, and educational value. This is in line with Zhou and colleagues [3] research, concluding that AR can attract students' attention and encourage them to be involved with problems more deeply [35]. However, enhancements in instructional design and user guidance can further optimize the learning experience. Moreover, the app suffers from personalization options, which are emphasized in the literature [23]. By addressing individual differences [23] and ensuring clear step-by-step instructions [20, 21] , AR tools like this can serve as powerful resources for teaching multiplication, fostering both engagement and learning outcomes in young students.

This research has applications in the field of teaching and learning. The use of augmented reality (AR) can increase the motivation [12, 14] and participation [6, 17] of students in learning mathematics by providing visual and interactive content and making complex concepts, such as multiplication, more attractive and understandable. The technology can also replace traditional memorization-based methods with interactive learning methods that help students practically understand abstract concepts. The findings of this research are useful for developers of educational software and can help to design applications suitable for children, with features such as large buttons, simple menus, and personalization options.

Moreover, AR technology can also be used in the education of students with special needs, as it reduces learning limitations by adding audio and visual capabilities. App usability evaluation using tools such as the SUS questionnaire helps teachers and developers identify and improve the strengths and weaknesses of educational programs. Also, by emphasizing features such as gamification, personalization, and audio and visual guidance, this research provides solutions to improve children's learning experience and create a sense of achievement in them.

Overall, multisensory learning models and constructivism are recommended in the design of technology-based educational programs. However, to optimize this process, aspects such as providing a personalized learning path, adding visual and auditory guidance, and increasing social interaction within the learning environment need to be implemented in the educational tool.

Conclusions

This research showed that using augmented reality applications to teach multiplication to children not only provides an engaging and interactive learning experience but can also have a positive impact on understanding abstract concepts and increasing students' motivation. The usability evaluation of this program using a localized version of the SUS questionnaire for children showed that most students found this software understandable, enjoyable, and easy to use, and were willing to continue using it. However, some weaknesses were also identified, such as the lack of audio and visual guidance, lack of customization capabilities, and lack of gamification elements (such as scoring or a sense of progress) that could be addressed in future versions.

From an educational design perspective, this program made learning more engaging for children by using interactive design principles, 3D images, and immediate feedback. Also, providing a Persian version of the system usability questionnaire for children is an innovative step in evaluating digital educational programs.

Overall, the results of this study show that the design of augmented reality educational programs should be based on the cognitive, physical, and social-emotional needs of children and on the principles of usability and user-centered design so that they can be effectively used in the teaching-learning process.

The limitation of this research is the low number of participants. Moreover, this study was conducted in a private school in which most students are from high-income families and are familiar with using mobile applications. This may impact how they evaluate the application. Another limitation of this research is that only the usability of one AR application is investigated.

An important priority for future research is to increase the sample size and diversity of the statistical population, especially to include students from diverse backgrounds such as public schools, low-income areas, or students with special needs. Increasing the number of students and experimenting with the use of the AR application in other schools with different characteristics, such as schools in low-income areas, may clarify more aspects of designing effective AR applications for teaching math, specifically multiplication.

Enhancing the pitfalls of this app and developing personalization features, adding gamification elements such as scoring, badges, and advanced stages can make the user experience more engaging for students and enhance their sense of progress. Therefore, it is recommended to add these features to the app and investigate their impact on students' engagement and motivation.

Expanding the application of this technology to other algebra subjects and designing similar applications for them is another important research area.

Authors' Contribution

N. Zanjani developed the idea, prepared the SUS questionnaire, analyzed data, and wrote the manuscript. F. Fathi bought and installed the app, worked on lesson plans with the children, and helped them answer the questionnaire. M. Ajdadi, as the consultant, designed the class implementation. M.J. Eslampoor supervised the project.

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Conflicts of Interest

The authors have no conflicts of interest.

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ORIGINAL RESEARCH PAPER

Identifying the opportunities of artificial intelligence for teacher leadership in the education process

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ABSTRACT

Background and Objectives: The 21st century has witnessed the rapid advancement of technologies that have transformed human life. Artificial intelligence, one of these emerging technologies, has the potential to fundamentally change various sectors, including education. In recent years, artificial intelligence has been utilized in educational systems to enhance the quality of learning and teaching. This research, considering the increasing importance of artificial intelligence in education and its impact on the role of teachers, conducts a thorough examination of the role of this technology in teacher leadership in the educational process and seeks to identify the opportunities presented by artificial intelligence for improving teachers' leadership and performance.

Methods: The present research is qualitative and of a narrative nature. The study population consisted of a total of 70 articles, from which 30 articles were selected based on acceptance criteria. The critical Glaser tool was also used to ensure the quality of the selected articles. For data analysis, a coding method was employed, initially extracting 162 open codes. Subsequently, 18 axial codes were identified, and finally, 3 selective codes representing the opportunities of artificial intelligence in teacher leadership during the educational process were recognized.

Findings: The findings of the research indicated opportunities for artificial intelligence in teacher leadership in the educational process across three categories:1.Planning: Assisting teachers in delivering intelligent content to students, providing information about students' educational backgrounds, automated scheduling and planning of lessons, designing customized training, offering teaching methods based on individual student needs, and providing intelligent platforms for self-learning.2. Implementation: Making the teaching process more engaging through chatbots, fostering active student participation in the learning process, improving the quality of education and the learning experience, creating independent learning opportunities for students, personalized instruction, and providing an exploratory learning environment.3.Evaluation: Automated grading of assignments and exams, providing feedback on the effectiveness of educational performance, managing data related to the evaluation of assignments and exams, assisting students in improving their learning, predicting students' academic performance, and making data-driven decisions based on evaluations.

Conclusions: Artificial intelligence serves as a transformative force in the field of education, playing a central role in improving the quality and personalization of the learning process. AI can be used as a powerful tool to enhance teacher leadership and improve the overall educational process. This technology offers tools for lesson planning, enhances teaching methods, and accurately assesses student performance. It not only assists teachers in their leadership roles but also provides access to extensive educational resources and enables immediate feedback.

By analyzing learning data, AI facilitates the provision of personalized educational content tailored to the individual needs of each student. In this way, it helps optimize the learning experience and increases interaction between teachers and students. The educational implications of AI technology will transform how students learn and how teachers operate. Ultimately, the use of artificial intelligence in education will improve educational systems, leading to enhanced learning quality and improved student outcomes worldwide.

NUMBER OF REFERENCES 34
NUMBER OF FIGURES 1
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مقاله پژوهشی

شناسایی فرصت‌های هوش مصنوعی بر رهبری معلمان درفرایند آموزش

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چکیده

پیشینه و اهداف: قرن بیست و یکم شاهد پیشرفت شتابان فناوری‌ها بوده که زندگی بشر را متحول کرده‌اند. هوش مصنوعی، یکی از این فناوری‌های نوظهور، پتانسیل تغییر اساسی در بخش‌های گوناگون، از جمله آموزش، را دارد. در سال‌های اخیر، هوش مصنوعی در نظام‌های آموزشی مورد استفاده قرار گرفته تا کیفیت یادگیری و آموزش را ارتقا بخشد. این پژوهش با توجه به اهمیت روزافزون هوش مصنوعی در آموزش و تأثیر آن بر نقش معلم، به بررسی نقش این فناوری در رهبری معلمان در فرایند آموزشی پرداخته و می‌کوشد فرصت‌های موجود در هوش مصنوعی برای بهبود رهبری و عملکرد معلمان را شناسایی کند.

روش‌ها: پژوهش حاضر کیفی از نوع روایت پژوهی بود. جامعه پژوهش شامل کلیه مقالات به تعداد ۷۰ بود که از این میان ۳۰ مقاله براساس معیارهای پذیرش انتخاب شد و از ابزار حیاتی گلین نیز برای تأمین کیفیت مقالات استفاده شد. به منظور تحلیل داده‌ها از روش کدگذاری استفاده شد که ابتدا ۱۶۲ کد باز استخراج شد، سپس ۱۸ کد محوری و در نهایت ۳ کد انتخابی به عنوان فرصت‌های هوش مصنوعی بر رهبری معلمان در فرایند آموزش شناسایی شد.

یافته‌ها: یافته‌های پژوهش فرصت‌های هوش مصنوعی بر رهبری معلمان در فرایند آموزش را در ۳ بعد نشان داد که شامل شد؛ ۱- برنامه‌ریزی: کمک به معلمان در ارائه محتوای هوشمند برای دانش‌آموزان، ارائه اطلاعات در مورد پیشینه‌آموزشی دانش‌آموزان، زمان‌بندی و برنامه‌ریزی دروس به صورت خودکار، طراحی آموزش‌های سفارشی شده، ارائه روش‌های تدریس بر اساس نیازهای فردی دانش‌آموزان، ارائه بسترهای هوشمند برای خودیادگیری؛ ۲- اجرا مانند: جذاب تر کردن فرآیند تدریس از طریق چت‌بات‌ها، مشارکت فعال دانش‌آموزان در فرایند آموزش، بهبود کیفیت آموزش و تجربه یادگیری، ایجاد یادگیری مستقل برای دانش‌آموزان، تدریس شخصی سازی شده، محیط یادگیری اکتشافی؛ و ۳- ارزشیابی مانند: نمره‌دهی خودکار به تکالیف و امتحانات، ارائه بازخورد در مورد اثربخشی عملکرد آموزشی، مدیریت داده‌های مربوط به ارزیابی تکالیف، امتحانات، کمک به دانش آموزان برای بهبود یادگیری، پیش بینی عملکرد تحصیلی دانش‌آموزان، تصمیم‌گیری مبتنی بر داده‌های ارزیابی بود.

نتیجه‌گیری: هوش مصنوعی به عنوان یک نیروی تحول‌آفرین در عرصه آموزش، نقشی محوری در بهبود کیفیت و شخصی‌سازی فرآیند یادگیری ایفا می‌کند. هوش مصنوعی می‌تواند به عنوان ابزاری قدرتمند در ارتقاء رهبری معلم و بهبود کلی فرآیند آموزش مورد استفاده قرار گیرد.این فناوری با ارائه ابزارهایی برای برنامه‌ریزی درسی، بهبود روش‌های تدریس و ارزیابی دقیق عملکرد دانش‌آموزان، نه تنها به معلمان در ایفای نقش رهبری کمک می‌کند، بلکه امکان دسترسی به منابع آموزشی گسترده و ارائه بازخورد فوری را نیز فراهم می‌سازد. هوش مصنوعی با تحلیل داده‌های یادگیری، امکان ارائه محتوای آموزشی شخصی‌سازی شده و متناسب با نیازهای فردی هر دانش‌آموز را فراهم کرده و از این طریق، به بهینه‌سازی تجربه یادگیری و افزایش تعامل بین معلم و دانش‌آموز کمک می‌کند. این پیامدهای آموزشی فناوری هوش مصنوعی، نحوه یادگیری دانش‌آموزان و شیوه فعالیت معلمان را متحول خواهد کرد. در نهایت، استفاده از هوش مصنوعی در آموزش، بهبود سیستم‌های آموزشی فراهم را به همراه خواهد داشت که می‌تواند به کیفیت آموزش و بهبود نتایج تحصیلی دانش‌آموزان در سرتاسر جهان منجر شود.

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Introduction

Artificial intelligence (AI) is a broad term encompassing various analytical methods, including machine learning, neural networks, and deep learning [1]. Generally, AI can be defined as the application of computers, machines, and other tools that exhibit behaviors similar to human intelligence. These behaviors include cognitive abilities, learning, adaptation, and decision-making. In other words, AI is a collection of computer programs and technologies that attempt to mimic the function of the human brain and intelligence [2]. Furthermore, Artificial intelligence is the ability to imitate human intelligent behavior under any conditions [3]. This technology allows us to perform tasks effectively and efficiently. Artificial intelligence is not only a source of modern knowledge and information, but it is also a branch of computer science that focuses on the development of machine intelligence and patterns of thought and behavior similar to those of humans. The impact of artificial intelligence on our daily lives is extensive and is clearly evident in search engines, mobile applications, and healthcare systems [4].

Artificial intelligence (AI), a dynamic and evolving phenomenon, has found widespread applications in various fields. AI's entry and influence on educational environments and the teaching-learning processes in schools are undeniable. As this trend continues, awareness and understanding of AI's importance in education are growing. The rapid development of AI in recent years has highlighted the necessity and feasibility of its use within educational systems. Simultaneously with global scientific and technological advancements, AI has also experienced significant improvements and enhancements. AI, by revolutionizing teaching and learning methods and developing innovative educational programs, has become a significant and important area of focus in educational research [5].

Modern technologies have brought significant transformations to teaching and learning methods. Schools are increasingly leveraging artificial intelligence to enhance various aspects of the educational process [6]. AI algorithms enable personalized learning experiences by analyzing student performance data to address individual needs [7]. Applications of AI in education are diverse. These include its integration into educational tools like chatbots [8], intelligent tutoring systems, and automated grading systems. These AI-powered systems create numerous opportunities for all stakeholders in the teaching and learning process [6].

Shen et al. [9] identified technological literacy as a fundamental competency, emphasizing the need for teachers to effectively understand and utilize AI-based tools, data analysis, and educational technologies. These researchers highlighted adaptability and continuous learning as essential skills for embracing new technologies, emerging pedagogical approaches, and evolving roles. Consequently, it is recommended that educational leaders participate in ongoing professional development and stay abreast of the latest advancements in artificial intelligence. Furthermore, teachers must adapt their pedagogical practices to effectively integrate AI tools and resources. This will allow for maximizing the potential of AI and providing richer learning experiences for students.

Using predictive artificial intelligence analysis, teachers can identify students at risk of academic decline and provide timely support [10]. Furthermore, natural language processing (NLP) tools can analyze student writing and provide feedback on grammar, spelling, and other writing skills [11]. Additionally, AI tools utilized by teachers include chatbots, which can answer student and parent questions about procedures, schedules, and other information instantly [12]. These technologies play a significant role in enhancing the quality of education and fostering constructive interaction between teachers and students.

Virtual assistants and voice recognition tools are increasingly utilized to support administrative tasks such as scheduling, record-keeping, and communications [13]. Additionally, some schools are experimenting with AI-based educational assistants that can help teachers with grading assignments, identifying student learning gaps, and suggesting personalized educational materials [14].

Using these tools, teachers can more effectively and efficiently handle various administrative tasks, such as reviewing and grading student assignments, allowing them to dedicate more time and resources to the educational aspects of their work. Furthermore, as AI leverages machine learning, curricula and content are customized and personalized to meet the individual needs of each student. This enhances student engagement and retention, ultimately improving the learning experience and overall quality of education [6]. The benefits of AI in education are increasingly recognized for providing specialized support, addressing knowledge gaps, facilitating effective learning and instruction, and enabling timely assessments of complex skills and knowledge [15].

Furthermore, it is believed that AI-powered educational systems can analyze classroom dynamics. This can help teachers better understand students' learning needs and behaviors, optimizing their teaching approaches. These capabilities can contribute to creating personalized and flexible learning environments, leading to improved academic results and a more positive learning experience for students. AI empowers teachers to make more informed decisions based on data, creating engaging and student-centered learning experiences that yield a more positive impact on student learning outcomes. AI also represents a transformative change in school curricula and national frameworks, enabling real-time monitoring of the learning process. These tools assist teachers in adapting content to meet students' needs and enhance their engagement in school activities [5-9-16].

Recent studies have demonstrated how artificial intelligence can be constructively integrated into and utilized in classrooms [17]. Given that the application of AI in education requires substantial changes in pedagogy, teachers must seriously consider updating the strategies and tools they employ in their curricula. Furthermore, they should leverage their professional judgment to effectively incorporate AI into the classroom setting [17].

In a study by Ghamrawi et al. [18], a group of teachers viewed artificial intelligence as a tool that could enhance their instructional leadership. They highlighted AI's potential to automate administrative tasks, provide data-driven insights, and free up teachers' time to focus on instructional leadership, guiding students, and innovating in the classroom.

Furthermore, as Salas-Pilco et al. [19] suggest, data-driven decision-making has emerged as a key competency. This competency emphasizes the need for teachers to analyze and interpret data generated by AI systems to inform instructional strategies, personalize learning experiences, and guide evidence-based decision-making. Currently, educational and administrative teams are re-evaluating their roles and work methods, as some existing practices are no longer effective in the new educational paradigm [20]. While AI can help reduce the heavy administrative and managerial burdens faced by school leaders, it may also potentially weaken leadership functions.

However, assessment processes will inevitably become more challenging, as the range of AI products available to students is complex and easily accessible [21]. In such circumstances, teachers need not only to leverage new technologies but also to rely on their analytical and evaluative abilities to ensure their positive impact on the learning process.

AI-assisted education encompasses various aspects, including intelligent tutoring, innovative virtual learning, and data analysis and prediction. These technologies offer new possibilities for evaluating students and schools and developing adaptive and personalized learning methods [22]. Overall, the integration of AI into educational processes can lead to a more engaging and effective learning experience, benefiting both students and teachers

Ultimately, in today's fast-paced world, traditional teaching methods are slow and inefficient, failing to deliver modern scientific and educational concepts with the power and excitement that today's generations of students require. Furthermore, teachers are not optimally able to review student performance and modify teaching techniques to suit their needs [23]. Today, traditional teaching and learning methods are not meeting the needs of learners; as a result, learners do not experience the joy of learning, and school becomes tedious for them. One solution to address these problems is to employ innovative methods in education.

Given that artificial intelligence is increasingly being used in educational settings, it is crucial to examine how it affects teacher leadership in the educational process. It is believed that the introduction of AI technologies in education changes the roles and responsibilities of teachers in schools.

Ultimately, the goal of the present research is to answer the question: What are the opportunities of artificial intelligence for teacher leadership in the education process?

Review of the Related Literature

AI technologies, by leveraging big data, enable increased customization and targeting of educational needs at the individual level. These technologies help adapt the curriculum and understand the needs of each student in the teaching and learning process. The use of platforms in education improves the relationship between teacher and student and guides the learning process according to the characteristics of each individual. Furthermore, these technologies help teachers tailor content to the needs of the school and increase participation in school activities [24].

Artificial Intelligence in education refers to the application of AI technologies, such as intelligent tutoring systems, cohabits, and automated assessment, as well as all forms of digital artifacts that support and enhance education. AI in education has great potential to improve learning, teaching, assessment, and educational management by providing learners with more personalized and adaptive learning, enhancing teachers' understanding of the learning process, and providing machine-supported inquiries at any time and immediate feedback [25].

The technologies can be used in providing customized educational content, supporting the professional development of educators, personalized teaching, intelligent teachers, intelligent education, personalized/adaptive learning, chatbots, automated grading of assignments and exams, teaching evaluation, personalized feedback, time management, international collaborations between educational systems in the context of AI, and automating administrative tasks [26].

UNESCO [27] proposes that it is now time to prepare the next generation of students for a future in which AI is an increasingly important part of their lives. They propose that AI educational tools should be integrated into curricula policies accordingly. The European Commission [28]. Recently, it published a guide that contained advice for educators and school administrators, which concluded:

From the way we stay informed to the way we make decisions, artificial intelligence (AI) is becoming ubiquitous in our economy and society. Naturally, it has reached our schools as well. AI in education is no longer a distant future. It is already changing the way schools, universities, and educators work and our children learn. It is making educational settings more responsive by helping teachers address each learner's specific needs. It is fast becoming a staple in personalized tutoring and in assessment.

And it is increasingly showing its potential to provide valuable insights into student development. The impact of AI on our education and training systems is undeniable and will grow further in the future.

Cooper [29] considers the impact of AI as a fundamental shift in education globally, noting that technologies like ChatGPT have immense potential to improve various aspects of education, including learning, teaching, educational innovations, assessment, and educational management. This potential can be leveraged through intelligent tutoring systems, catboats, and robots, learning analytics dashboards, adaptive learning systems, and automated assessment.

Chen et al. [6], in their study, emphasized that improving learner outcomes requires designing teaching methods based on their personal data. This approach helps teachers provide immediate and accurate feedback and perform administrative tasks such as reviewing and grading student assignments more effectively and efficiently. By using AI, the curriculum and educational content are customized and personalized according to the needs of students, which helps to attract and retain students and improves the learning experience and overall quality of the teaching-learning process.

Celik et al. [30], added that AI provides numerous opportunities for teachers to improve planning, implementation, and assessment. This technology can help define student needs, familiarize teachers with these needs, and enhance teaching quality by providing immediate feedback and educational interventions. It also facilitates the assessment process by using automated essay grading. These approaches allow teachers to optimize their teaching and improve student learning outcomes.

Almasri [31] in his research showed that AI-based tools can help improve the learning environment, create exams more efficiently, conduct more accurate evaluations of student work, and also predict their academic performance. These tools, by analyzing educational data and providing instant feedback, can improve the quality of student learning and help teachers tailor their teaching methods to the individual needs of students. In addition, AI can be effective in reducing the administrative burden on teachers and optimizing assessment and educational management processes. Thus, it can be said that AI acts not only as a technological tool, but also as a key factor in the transformation of education and learning.

AI can host intelligent content and enable independent learning. This technology improves virtual learning environments by analyzing student data and enabling the customization of content and educational delivery methods based on the individual needs of students. In addition, AI, by automating tasks such as correcting papers and providing feedback, allows teachers to focus on their other essential and important responsibilities. This automation not only frees up teachers' time but also helps them to provide more accurate and personalized analyses to students, thereby improving the quality of education [32].

Based on previous research, this study aims to identify the opportunities that artificial intelligence presents for teacher leadership in the educational process.

Method

The study used a qualitative approach, specifically narrative research. Narrative research is a method that combines and analyzes a collection of extensive and scattered articles on a topic, creating a bridge for a reader who does not have enough time and resources to follow all those scattered sources [33]. This method is specifically carried out in four steps, each of which has specific details as follows:

Implementing the Search Strategy

At this stage, among domestic and foreign databases (such as SID, Normags, Elsevier, Scopus, ProQuest, and Sage), six reputable databases were reviewed using the keyword "Artificial Intelligence in Education and Learning" for the period from 2020 to 2024. Article acceptance criteria include research language, study area, research methodology, acceptable study specifics and details, study type, and indexing, as listed in Table 1.

Table 1: Article Acceptance Criteria

Acceptance Criteria	
Research Language	Persian/English
Research Timeline	2020-2024
Area of Study	Artificial Intelligence in the Learning Process
Research Method	Qualitative/Quantitative/Mixed Methods
Conditions and Details for Study Acceptance	Opportunities of Artificial Intelligence in Education and Learning
Study Type	Articles Published in Reputable Research Journals
index	Elsevier, Scopus, ProQuesr, SAGE, SID, Noormags

Stage Two: Collecting Scientific Documents

In this phase, an initial review of the articles available in domestic and international academic databases was conducted, leading to the analysis of 70 articles. Each of these articles included concepts or keywords relevant to the focus of this research.

Selection and Choice

At this stage, from among 70 collected scientific documents, 25 foreign and 5 Persian articles, totaling 30 scientific articles, were selected and analyzed using a coding method (Table 2). To ensure the validity of the research findings, a structured process of recording and writing research findings, as well as self-review by the researcher, was used. Additionally, to ensure the quality of the content of the documents, a critical evaluation method was employed using the Glynn critical appraisal tool. This tool provides a comprehensive list of questions (Value of the Research, Clear and Explicit Presentation of Findings, Accuracy of Data Analysis, Ethical Considerations, Data Collection, Sampling Method, Research Design, Logic of Method, Research Objectives. Of the 30 articles, each was assessed using a Glynn tool and a nine-question questionnaire, with each question rated on a scale of 1 to 5. The total score for each article was determined based on the following standardized scale: 1.33 to 2.33, weak; 2.33 to 3.66, moderate; and 3.66 to 5, good. Ultimately, five articles were assessed as moderate, and twenty-five were assessed as good. Table 3

Analysis of Scientific Documents

The scientific documents collected in the previous stages were studied and analyzed, and the findings were organized in the form of a table (Table 4). The findings were organized first by extracting relevant statements from the article texts and assigning a concept to each. Then, similar and related concepts were categorized and named as categories.

Table 2: Introduction of Reviewed Articles

Article Code	Authors	Year of Publication	Article Code	Authors	Year of Publication
1	Ghamrawi	2024	16	Sharawy	2023
2	Kurkan& Cetin	2024	17	Ishfaq. Vijaya	2023
3	Papadakis et al.	2024	18	Lameras& Arnab	2022
4	Filgueiras	2024	19	Celik et al.	2022
5	Arar et al.	2024	20	Nalbant	2021
6	karakose & Tulubaş	2024	21	Haefner et al.	2021
7	Onome &Olasumbo	2024	22	Huang et al.	2021
8	Fullan et al.	2024	23	Wang	2021
9	lmasri	2024	24	Hashem Mahmoud	2020
10	Tang	2024	25	Chen et al.	2020
11	Chen et al.	2023	26	khabareh	2024
12	Kamalov et al	2023	27	Rezaei& Abdollahi	2023
13	Cooper	2023	28	Dadashpour, & Dehghanpour	2023
14	Zhang& Mao	2023	29	Bahijab et al.	2023
15	Alier et al.	2023	30	Nader	2022

Table 3. Vital Assessment Tools

Article Code	Value of the Research	Clear and Explicit Presentation of	Accuracy of Data Analysis	Ethical Considerat	Data Collection	Sampling Method	Research Design	Logic of Method	Research Objectives	Summary	Evaluation
1	5	5	5	5	5	5	5	5	5	5	Good
2	5	5	5	5	5	5	5	5	5	5	Good
3	4	4	5	5	5	5	4	3	5	4.44	Good
4	4	4	3	4	3	3	3	3	5	3.55	average
5	4	5	5	4	3	3	4	3	3	3.77	Good
6	5	4	5	4	4	5	5	5	4	4.55	Good
7	4	4	4	5	4	4	3	4	5	4.11	Good

Article Code	Value of the Research	Clear and Explicit Presentation of	Accuracy of Data Analysis	Ethical Considerat	Data Collection	Sampling Method	Research Design	Logic of Method	Research Objectives	Summary	Evaluation
8	5	5	5	5	5	5	5	5	5	5	Good
9	5	5	5	5	5	4	4	5	5	4.88	Good
10	5	5	5	5	5	5	5	5	5	5	Good
11	5	5	5	5	5	5	5	5	5	5	Good
12	5	4	5	4	4	5	5	5	4	4.66	Good
13	4	5	5	4	3	3	3	4	4	3.88	Good
14	4	5	4	4	3	4	4	4	5	4.11	Good
15	5	5	5	5	5	4	4	5	5	4.88	Good
16	4	5	4	4	3	3	4	4	5	4.11	Good
17	5	5	5	5	5	5	5	5	5	5	Good
18	5	5	5	5	5	5	5	5	5	5	average
19	5	5	5	5	5	5	5	5	5	5	Good
20	4	4	4	4	4	3	4	4	4	3.88	Good
21	5	5	5	4	5	٣	4	4	5	4.55	Good
22	5	5	5	5	5	4	4	5	5	4.88	Good
23	4	4	4	4	4	4	4	4	4	4	Good
24	5	5	5	5	5	5	5	5	5	5	Good
25	4	4	3	3	3	3	3	3	3	3.22	average
26	5	5	5	5	5	5	5	5	5	5	Good
27	5	4	5	4	5	4	4	4	5	3.50	average
28	5	5	5	5	5	5	5	5	5	5	Good
29	5	5	5	5	5	4	4	5	5	4.88	Good
30	4	5	4	5	4	4	4	4	5	4.33	average

Table 4: Coding of Artificial Intelligence and Teacher Leadership Findings in the Education Process

Row	Open Codes	Axial Codes	Selective Codes
1	Having technology literacy (1), rich and diverse collaboration with colleagues (2), virtual collaborations (2), saving time (2)(7), easier tracking of accountability (2), stimulating students' enthusiasm in the learning environment (22)(3)(23), collection, processing, and analysis of data (3); use of big data (4)(20)(11), innovation in teaching management (5), creating intelligent content for students (5), intelligent content can dynamically change and adapt depending on who reads it (5), providing educational materials (6); security, and processing of student information (6), learning analytics or educational data mining (6), providing customized education (6), processing large datasets (6), transparency in activities (6), participation and digital skills (6), integrating teachers, students, and parents in educational processes (6), necessary synergy to achieve educational goals (6), automation of tasks by automating processes (27)(8), helping to support and intervene with students (8), a long-term perspective (8); maintaining student records (7), reducing administrative errors (7), allocating more resources to core educational activities (7), improving the quality of education and the learning experience of students (7), changing teaching methods (9), artificial intelligence can host smart content (10), artificial intelligence improves virtual learning environments by analyzing student data (10); providing customized educational content (26)(10)(7), providing teaching methods based on individual needs (10)(26); learning analysis dashboards (13), providing adaptive learning systems (13), supporting and strengthening the educational process (13); updating the strategies and tools they use in their educational programs (14), also, they must use their professional judgment when planning to include artificial intelligence in the classroom (14), data analysis and simplified administrative processes (that artificial intelligence can automate repetitive administrative operations such as scheduling, admissions, and registration (15), designs the teaching method for each learner based on their personal data (25), providing intelligent platforms for self-learning (26), facilitating decision-making (29); providing curricula (11), adjusting the content and difficulty level of education based on individual needs (27), analyzing individual interests and needs (27).	Providing intelligent platforms for self-learning Providing intelligent content for students Providing information about students' backgrounds Automated scheduling and planning of lessons Designing customized education Providing teaching methods based on individual student needs	Planning
2	Evaluation processes will also inevitably become more challenging, as the scope of artificial intelligence products becomes increasingly complex and readily available to students(14), adaptability and continuous learning(1), collaborative and mentoring skills(1), faster communication capabilities(2), facilitating meetings(2), promoting better classroom management(3)(22),(23) supporting customized learning(3)(22)(23), increasing customization of learning(4), enabling the targeting of educational needs on an individual scale(4), allowing the adaptation of curriculum and understanding the needs of	Improving the quality of education and the learning experience	Implementation

Row	Open Codes	Axial Codes	Selective Codes
	each student in the teaching and learning process(4), the use of platforms in education(4), reforming the relationship between teacher and student(4), guiding the learning process according to the profiles drawn by each individual(4), increasing the creativity of teachers and students(3)(22)(23), adapting content to the needs of the school(4), helping teachers adapt content(4), improving the learning environment(9), increasing participation in school activities(4); creating new educational and learning modes(5), storing the previous learning history of students(17), personalized learning experiences(17), transcribing teacher lectures into local languages(17), access to classrooms without any limitations(17), creating smart content(17), adaptive learning(17), facilitating the learning process(17)(5)(29)., helping students apply knowledge(18), helping students become self-regulated learners(18), engaging students with adaptive learning tasks(18), task-oriented chatbots(18)(16), preparing and transferring educational content(18), content recommendation system(18), personalized content sequencing(18), tracking student attendance(20), personalization in education(20), distance learning(20), smart contents(20), virtual learning environments(20), personalized learning(20), intelligent educational systems(20), speech generation and language translation systems(20); school management must follow the learning needs of each student(21), produce and share appropriate content(21), more flexible curricula(21); intelligent teacher(22)(23)(26), cognitive educators or intelligent teachers that act as a conversation-based private tutor that supports learning(22), greater accuracy in understanding trends and problems in educational environments(22) smart learning(22)(26), intelligent education(24)(26), innovative virtual learning(24), educational activities achieve higher quality(25), since artificial intelligence uses machine learning, curriculum and content are customized and personalized according to student needs that enhance engagement and retention(25); improves the learner experience and overall quality of learning(25);: increased ability of trainers to teach(26), support for professional development of trainers(26), personalized/adaptive learning(26), conversational robots(26), intelligent and personalized teaching(27)(24), exploratory learning environment(26), individual counseling to learners(26)(27), facilitating education(29), active participation of students(11) improving learning(13), transformation in teaching(13), educational innovations(13), intelligent education systems, chatbots and robots(27)(13), personal learning(15), intelligent education(15), adaptive learning method(27)(24) personal learning approach(27)(24), digital assistants(27)(16)(24), adaptive and personalized learning(27)((16); generation of intelligent content(27)	Exploratory learning environment Personalized teaching Creating independent learning for students Active participation of students in the learning process Making the teaching process more engaging through chatbots	

Row	Open Codes	Axial Codes	Selective Codes
3	Data analysis and prediction(24), automated evaluation(13); scientific analysis(24), grading and evaluation of exams(24), learning analytics(24), improving learners' learning(25), providing feedback and instant grades(25)(16), reviewing and grading student assignments more effectively and efficiently(25), automated grading of assignments and exams(26), controlling the learning process(26), predicting learner performance(26), evaluating teaching(26), personalized feedback(26); understanding more efficient resource allocation(28), faster and more accurate automation of administrative tasks(28); timely detection of problems in the performance of the educational system(28), providing data analysis(8), transformation in evaluation strategies and administrative processes(9), creating automatic tests(9), evaluating student work(9), predicting academic performance(9); evaluation of all students(21)(24), educational evaluation and management(13), helping students improve learning through evaluation and feedback(18), web-based intelligent feedback systems(18), intelligent evaluation systems(20)(28), changing teachers' teaching methods(12), changing students' learning(12), changing the performance of schools(12); retrieval of personal information(18), access to information(20), artificial intelligence, by automating tasks such as correcting papers and providing feedback, allows teachers to focus on other essential responsibilities(10); data and evidence-based decision-making(3)(1)(6); creating and evaluating effective educational policies(23)(22), improving administrative functions(11), predicting trends and automating routine tasks(11); managing data related to the evaluation of assignments, exams(21), innovation in evaluation systems(5); immediate feedback to learners(15), providing accurate and immediate feedback to the learning process(30), evaluating individual performance and providing suggestions for improvements to enhance learning(30), recommending appropriate educational resources and providing personalized guidance(30), analyzing and predicting student performance(30)(27), adaptive tests(27)	Data-driven decision-making Automated grading of assignments and exams Providing feedback on the effectiveness of teaching performance Helping students improve their learning Predicting students' academic performance Managing data related to the evaluation of assignments and exams	Evaluation

Results and Discussion

The findings were organized by first extracting related statements from the articles and assigning a concept to each. Similar and related concepts were then categorized and named as categories. Based on the research findings, artificial intelligence opportunities for teacher leadership in the instructional process were categorized into three main domains: planning, implementation, and evaluation (Figure 1). Figure 1 provides a detailed analysis of these findings.

Planning

AI offers transformative possibilities in the planning phase, enabling teachers to design instruction more efficiently and effectively. Key opportunities include:

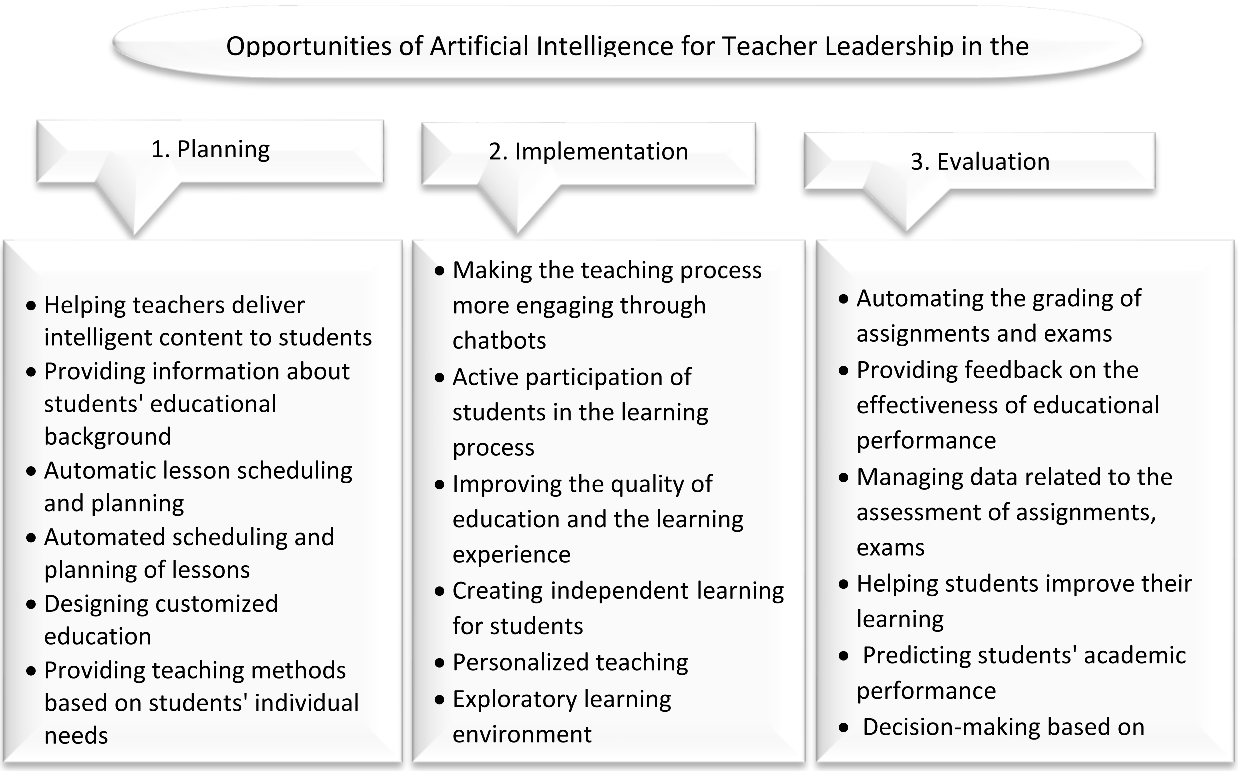

Fig. 1: Artificial Intelligence Opportunities for Teacher Leadership in Education

- Providing Intelligent Content: AI can help teachers provide appropriate and up-to-date educational content for students. This intelligent content can be designed to match the learning needs of each student.
- Providing information about students' educational background: Using AI data, teachers can have accurate information about each student's educational background, which helps them personalize instruction for the best possible results.
- Automated Planning and Scheduling: With AI-based tools, teachers will be able to intelligently schedule and plan lessons. This can lead to greater efficiency and reduce the stress associated with organizing lessons.
- Designing Customized Instruction: One of the important features of AI is the ability to design personalized training courses for each student based on their individual abilities and needs.
- Providing teaching methods based on individual student needs: AI can enable teachers to design teaching methods appropriate to each student's specific needs.
- Providing intelligent platforms for self-learning: Intelligent platforms can help students learn independently and autonomously, which can be very effective in developing self-directed learning skills.

AI offers significant potential to enhance educational planning by providing tools for teachers to create more effective and personalized instruction. It can facilitate access to intelligent content, offer insights into students' backgrounds, automate lesson scheduling, and enable customized learning paths. Ultimately, these AI capabilities aim to empower teachers to cater to diverse student needs and foster self-directed learning. This ultimately leads to a more efficient and less stressful teaching experience [24-26-32].

Chelik et al. [30], noted that artificial intelligence provides teachers with valuable opportunities to enhance educational planning, implementation, and assessment. This technology improves teaching quality by identifying students' needs, informing teachers about these needs, and enabling rapid feedback and targeted interventions. Furthermore, by automating exam grading, it simplifies the evaluation process. Such solutions help teachers optimize their teaching methods and strengthen students' learning outcomes.

Cooper [29], also considers artificial intelligence to be a fundamental transformative factor in global education. He notes that technologies such as ChatGPT have significant potential to enhance various aspects of education, including the learning process, teaching, educational innovations, assessment, and educational management. This potential can be realized through intelligent educational systems, chatbots, robots, learning analytics dashboards, adaptive learning systems, and automated assessments.

Furthermore, Filgueiras [24], emphasizes in their research that AI technologies, by leveraging big data, enable increased customization and targeting of educational needs at the individual level. These technologies contribute to improving the learning process by adapting curricula and understanding the educational needs of each student. The use of educational platforms, while improving the relationship between teachers and students, guides the learning process based on the individual characteristics of each student. Additionally, these technologies help teachers align educational content with the needs of the school and increase student participation in school activities

Implementation

The advancements in the planning phase create an optimal foundation for effective implementation, where AI dynamically enhances classroom interactions and enriches learning experiences. Such as:

- Making the teaching process more engaging through chatbots: The use of chatbots and AI systems for increased interaction with students can add more engagement to classroom activities. Chatbots serve as interactive tools that encourage students to ask questions and engage with educational content.
- Active participation of students in the learning process: AI can assist teachers in creating interactive environments and educational challenges where students actively participate in the learning process.
- Improving the quality of education and learning experience: AI tools enable teachers to optimize the learning process for each student, enhancing the overall quality of education.
- Creating independent learning for students: By providing intelligent resources and tools, students can take control of their learning process and learn independently from the teacher.
- Personalized teaching: AI can empower teachers to tailor their instruction for each student and offer teaching methods that align with individual learning needs.
- Exploratory Learning Environment: AI can provide tools to create exploratory learning environments where students can actively gain new educational experiences.

These applications of AI not only foster a more engaging classroom atmosphere but also empower students to take charge of their learning, promoting a deeper understanding and retention of knowledge. As teaching evolves with the integration of AI technologies, the role of the teacher transforms into that of a facilitator who guides students through their personalized learning journeys. The findings of studies by Gamrawi [18] and Chen et al. [6], have pointed to some of these issues.

In their research, Thomas et al. [25] define Artificial Intelligence in Education as the application of AI technologies, including intelligent tutoring systems, chatbots, automated assessment, and all digital tools that support and enhance education. They believe that AI in education has significant potential to improve learning, teaching, assessment, and educational management by providing learners with more personalized and adaptive learning experiences, enhancing teachers' understanding of the learning process, and enabling instant question-and-answer support with machine assistance.

As Khabareh [26] has demonstrated in his research, artificial intelligence technologies possess numerous capabilities in the field of education. These capabilities include providing customized educational content, supporting professional development for educators, personalized instruction, the use of intelligent teaching methods, personalized and adaptive learning, conversational robots, automatic grading of assignments and exams, assessing teaching methods, delivering personalized feedback, time management, international collaboration among educational systems utilizing artificial intelligence, and automating administrative tasks.

Artificial intelligence and new technologies provide students and teachers with access to a variety of rich educational resources such as educational videos, educational software, electronic books, and educational articles. These technologies, by creating interactive opportunities, facilitate the learning process and encourage students to participate more actively in this process [34].

Evaluation

The valuable data generated during the implementation process flows into the evaluation phase—a stage where AI elevates outcome quality by optimizing both assessment procedures and feedback systems. Such as:

- Automating the grading of assignments and exams: AI has the ability to automatically grade assignments and exams. This can reduce the workload for teachers and increase the accuracy and speed of evaluations.
- Providing feedback on the effectiveness of educational performance: AI systems can provide detailed feedback on the effectiveness of teachers' teaching methods, helping them make necessary improvements in their instructional strategies.
- Managing data related to the assessment of assignments, exams: Collecting and analyzing data related to assignment and exam evaluations can help teachers identify patterns and trends in student performance, enabling better decisions about instruction.
- Helping students improve their learning
- Predicting students' academic performance: AI can use existing data to predict students' academic performance. These predictions can help teachers address issues before they escalate.
- Decision-making based on assessment data: AI helps teachers make decisions based on accurate data and intelligent analysis, which can improve educational processes and academic outcomes.

These applications of AI in evaluation can create a more efficient, fair, and insightful assessment process. Teachers can utilize the data and feedback provided by AI systems to better understand student learning patterns and adapt their instruction to meet individual needs. Furthermore, the predictive capabilities of AI can help in identifying students at risk and providing early interventions, ensuring that all students have the opportunity to succeed, which aligns with the findings of Zhang and Mao [21], Hashem Mahmoud [22].

According to the research by Rezaei and Abdollahi [34], the applications of artificial intelligence in the education process include: personalized learning, suggesting suitable content, analysis, and prediction of student performance. Additionally, chatbots and virtual assistants, adaptive testing, automated content generation, global access, intelligent content creation, and task automation through process automation are also among the applications.

This is a finding that comes parallel to many of the revised studies, such as Bertolin and Da Rin [12], Shen et al. [9], and Zhai et al. [16]. These teachers saw AI as empowering them to make informed decisions based on data, create engaging and student-centered learning experiences, and amplify their impact on student learning outcomes.

Additionally, Al-Masri's [31] research has concluded that AI-based tools can enhance the learning environment. These tools can design tests more efficiently, provide more accurate assessments of student performance, and even predict their academic success. By analyzing educational data and offering instant feedback, artificial intelligence can improve the quality of student learning and assist teachers in tailoring their teaching methods to meet the specific needs of each student.

The limitations of this research include the reliance solely on research articles for data collection. While interviews with experts would have provided valuable insights, this was not possible due to a lack of access to such individuals. Furthermore, considering the importance of artificial intelligence in education in the last decade and the research conducted in this field, and also considering the nature of the narrative review method and the objective of examining a limited number of studies, data collection has focused on foreign research within the timeframe of 2019 to 2024. This limitation may affect the perspectives presented in the research.

The following recommendations are presented for future researchers in the field of artificial intelligence applications in education:

- Conduct longitudinal studies to evaluate the effects of artificial intelligence usage on students' academic progress, critical thinking skills, and lifelong learning over time.
- Perform comparative studies to analyze the achievements of students who have extensively utilized artificial intelligence in the educational process, in contrast to those who have employed traditional educational methods.
- Encourage and promote collaboration among researchers in the fields of educational sciences, computer science, psychology, and other related disciplines to conduct comprehensive and multifaceted research.
- Employ quantitative research methods to assess the effectiveness of artificial intelligence tools and utilize qualitative research methods to gain a deeper understanding of the experiences and perspectives of students and teachers.
- Investigate and study how the role of teachers is changing in classrooms equipped with artificial intelligence and identify the new skills that teachers need to effectively utilize these technologies.
- Develop training programs and empower teachers to optimally use artificial intelligence tools in teaching, assessment, and providing feedback.
- Conduct research on the challenges and issues related to the use of artificial intelligence in education, including the privacy of student information, algorithmic biases, and the impact of artificial intelligence on educational equity and equal access to learning opportunities.

Conclusions

This research investigated the potential of artificial intelligence (AI) to enhance teacher leadership within the educational process. A review of 30 articles identified key opportunities across three main domains: planning, implementation, and evaluation. In the planning phase, AI provides teachers with tools to optimize instructional design. These include intelligent platforms for self-learning, personalized content tailored to individual student needs, automated scheduling to streamline lesson planning, and data-driven insights to customize teaching methods effectively. In the implementation, AI enhances the quality and engagement of the learning experience. It supports exploratory learning environments, facilitates personalized teaching approaches, promotes independent learning opportunities for students, encourages active participation through interactive tools like chatbots, and enriches the overall educational environment. In the evaluation phase, AI streamlines assessment and feedback mechanisms. It enables data-driven decision-making through the automated grading of assignments and exams, provides predictive analytics to forecast student academic performance, and offers feedback on teaching effectiveness, allowing for continuous improvement.

Based on the research, AI applications in education are diverse and transformative. They encompass personalized learning pathways, adaptive content delivery based on student data analysis, predictive analytics to provide targeted feedback, virtual assistants for educational support, adaptive testing adjusted to student knowledge levels, automated content generation, enhanced access to global educational resources, and automation of repetitive tasks. These applications demonstrate AI's substantial capacity to optimize and improve the educational process. AI offers innovative solutions for personalizing education and providing immediate feedback, which can significantly increase student motivation and engagement. Traditional teaching methods often struggle to adapt to the demands of new generations and the rapid pace of scientific advancements. AI presents a vital solution for enhancing educational quality and providing valuable professional guidance to teachers. In a context requiring structural changes, integrating AI can optimize learning experiences and lead to fundamental improvements in educational systems.

Ultimately, emphasizing active and digital learning through the strategic integration of AI can drive transformative changes in education. Achieving this requires collaboration among researchers, educators, and policymakers to fully leverage AI's potential, shifting from conventional approaches toward the adoption of innovative, intelligent tools aligned with the evolving needs of students and scientific progress.

Based on the findings of the research, the following practical recommendations are offered:

- Participate in training courses and workshops that familiarize teachers with the applications of artificial intelligence in education. This will help them stay informed about the latest developments and AI tools in education.
- Provide financial and technical resources to implement AI tools in schools. This includes purchasing software, hardware, and staff training.
- Create an encouraging environment for teachers to use AI tools in creative and innovative ways.
- Establish policies that protect student privacy when using AI tools.

- Foster collaboration between universities and industry: Encourage collaboration between universities and technology companies to develop and commercialize AI tools in education.
- Use AI for translation and localization of educational content and access to international educational resources.
- Utilize intelligent educational platforms that adapt educational content and teaching methods based on the needs and knowledge level of each student.
- Provide specialized training courses for teachers to familiarize them with AI concepts and how to use AI-based tools in teaching and assessment.

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Conflict of Interest

The authors declare that there is no conflict of interest

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ORIGINAL RESEARCH PAPER

AI-Powered Flipped Instruction in Higher Education: Effects on Conceptual Understanding in Psychology of Language Learning

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ABSTRACT

Background and Objectives: Flipped instruction (FI) inverts the traditional lecture-homework model, engaging learners with content before class through a variety of technologies. AI in this regard can bring adaptability and interactivity to both the pre-class and in-class phases, especially in understanding scientific concepts in higher education courses. While there is growing research on the value of AI-assisted FI in subjects such as science and engineering, the impact of this revolutionary instructional practice in teacher education courses remains open to further research. This study employs a quasi-experimental design to investigate the effects of AI-assisted FI on the understanding of technical and scientific concepts in the course Psychology of Language Learning.

Materials and Methods: The participants included three groups of BA students who enrolled in the course Psychology of Language Learning (n=73). Group 1 (n=26) received AI-assisted FI, where pre-class instructional content was prepared by NotebookLM, an AI-powered research and writing tool. Group 2 (n=25) received conventional FI, where pre-class instructional content included the instructor's PowerPoints with voiceovers. Group 3 (n=22) received conventional instruction utilizing a lecture-based instructional approach. In-class phase activities included quizzes, group/pair work, completion of task sheets, question-and-answer activities, and oral discussions. Post-class reinforcement included summary writing, transcribing, and generating concept maps. The participants' achievement in the course and understanding of the technical concepts were assessed by the researcher-made midterm and final exams.

Findings: A two-way Multivariate analysis of Variance (MANOVA) was used to compare the participants' achievement in the course and understanding of the technical terms. The results illustrated a significant difference between the three groups in general achievement and in both the midterm and final exams of the course with a strong effect size. Tukey's HSD test showed that Group 1, who experienced AI-assisted FI, outperformed both Groups 2 and 3 in midterm and final exams. It was also found that Group 2, who learned the technical concepts using conventional FI, outperformed Group 3, who participated in a traditional and lecture-based course, in both exams. No difference was observed between male and female students.

Conclusions: The significant improvement in conceptual understanding among students who experience AI-assisted FI suggests that integrating AI tools, such as NotebookLM, can meaningfully enhance learning experiences by providing personalized, adaptive, and interactive pre-class content. This implies a shift in pedagogical design, from traditional, instructor-centered delivery models to learner-centered environments where students actively engage with content before class. Moreover, the use of AI in pre-class instruction supports differentiated learning by accommodating individual pacing and comprehension levels, thus promoting educational equality. For instructors, AI tools reduce the need for repetitive content delivery, enabling them to focus on facilitating higher-order learning, critical thinking, and collaborative in-class activities. From an institutional perspective, the successful application of AI-assisted FI in this study can reform curriculum development, faculty training, and the integration of AI tools into learning. Notably, while this study focused on educational psychology in ELT, the model has broad potential for transferability to other fields, particularly those requiring mastery of complex or technical concepts, such as engineering education, STEM curricula, or health education.

NUMBER OF REFERENCES 56
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NUMBER OF TABLES 5

مقاله پژوهشی

آموزش معکوس مبتنی بر هوش مصنوعی در آموزش عالی: اثر بخشی بر درک مفاهیم علمی در روانشناسی یادگیری زبان

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چکیده

پیشینه و اهداف: کلاس معکوس مدل آموزشی سنتی سخنرانی-محور را دگرگون کرده و فراگیران را با استفاده از فناوری‌های متنوع قبل از کلاس درس با محتوای آموزشی درگیر می‌کند. در این ارتباط، هوش مصنوعی می‌تواند قابلیت سازگاری و تعامل را به ویژه در آموزش مفاهیم علمی به مراحل پیش کلاسی و درون کلاسی بیافزاید. با وجود پژوهش‌های رو به رشد مرتبط با بکارگیری هوش مصنوعی در کلاس معکوس، تأثیر این فناوری در دوره های تربیت معلم نیازمند پژوهش‌های تکمیلی است. از این رو، این مطالعه با بکارگیری طرح شبه تجربی به بررسی تأثیر کلاس معکوس با کمک هوش مصنوعی بر عملکرد دانشجویان در درس روانشناسی یادگیری زبان می پردازد.

روش‌ها: شرکت کنندگان شامل سه گروه دانشجوی مقطع کارشناسی آموزش زبان انگلیسی بودند که در درس روانشناسی یادگیری زبان ثبت نام کرده بودند (۷۳ نفر). محتوای آموزشی گروه اول (۲۶ نفر) با استفاده از NotebookLM که یک ابزار هوش مصنوعی برای پژوهش، نگارش و تولید محتوی است آماده شد و آموزش معکوس از طریق آن صورت گرفت. گروه دوم (۲۵ نفر) کلاس معکوس را با استفاده از پاور پوینت های صداگذاری شده استاد تجربه کردند. گروه سوم (۲۲ نفر) درس را از طریق آموزش سنتی سخنرانی فرا گرفتند. فعالیت های درون کلاسی، شامل آزمون ها، کار گروهی/دو نفره، تکمیل برگه های تمرین، فعالیت های پرسش و پاسخ، و بحث های شفاهی بود. تمرین های پس از کلاس شامل خلاصه نویسی، پیاده کردن متن فایل های صوتی، و درست کردن نقشه های مفهومی بود. عملکرد و یادگیری مفاهیم علمی هر سه گروه از طریق آزمون های محقق ساخت میان ترم و پایان ترم مورد ارزیابی قرار گرفت.

یافته‌ها: برای مقایسه فراگیری مفاهیم علمی، از تحلیل واریانس چند متغیره دو سویه استفاده شد. نتایج نشان داد که بطور کلی بین عملکرد سه گروه شرکت کنندگان در درس روانشناسی یادگیری زبان تفاوت معناداری با ضریب تأثیر قوی وجود داشت. این تفاوت در بین آزمون های میان ترم و پایان ترم نیز معنادار بود. آزمون تعقیبی توکی نشان داد که گروه اول که آموزش معکوس با کمک هوش مصنوعی را دریافت کرده بودند، در هر دو آزمون عملکرد بهتری نسبت به گروه دوم و سوم داشتند. همچنین، گروه دوم که آموزش معکوس متداول را دریافت کردند، نسبت به گروه سوم که آموزش سنتی سخنرانی-محور را تجربه کردند، عملکرد بهتری داشتند. تفاوت معناداری بین عملکرد دانشجویان دختر و پسر مشاهده نشد.

نتیجه‌گیری: بهبود قابل توجه در عملکرد گروه کلاس معکوس با کمک هوش مصنوعی نشان می دهد که بکارگیری ابزارهای هوش مصنوعی مانند NotebookLM می تواند تجارب یادگیری را ازطریق شخصی سازی، سازگاری و تعامل با محتوای آموزشی تقویت کند. این موضوع نشان دهنده نیاز به تحول در طراحی مدل های آموزشی از روش های سنتی استاد-محور به محیط های یادگیرنده-محور است که در آن فراگیر بتواند بطور فعال با محتوای آموزشی قبل از دریافت آموزش درگیر شود. استفاده از هوش مصنوعی در کلاس معکوس می تواند آموزش را فردی سازی کرده و با در نظر

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گرفتن سرعت و توانایی درک مناسب هر دانشجو برابری آموزشی را ارتقا بخشد. ابزارهای هوش مصنوعی به اساتید کمک می کند تا بدون نیاز به ارائه های تکراری بر ارتقا یادگیری های سطح بالاتر، تفکر نقادانه، و فعالیت های گروهی درون کلاسی تمرکز بیشتری داشته باشند. از منظر سازمانی، بکارگیری موفق آموزش معکوس با کمک هوش مصنوعی می تواند انقلابی در طراحی برنامه درسی، تربیت مدرس و کاربست فناوری های نوین در آموزش ایجاد کند. با اینکه یافته های این مطالعه بر درس روانشناسی یادگیری در حوزه آموزش زبان متمرکز بود، مدل ارائه شده قابل تعمیم به سایر حوزه های آموزش مانند آموزش مهندسی، آموزش تلفیقی (STEM) و حوزه سلامت که بطور ویژه بر یادگیری مطلق مفاهیم پیچیده علمی تأکید دارند، است.

Introduction

With revolutionary advancements in computer science, creating intelligent machines and systems, Artificial Intelligence (AI) is becoming an integral part of modern society, exerting a considerable influence on all aspects of human life, from industry and healthcare to transportation and education. Being capable of performing tasks that typically require human intelligence, the potential of AI in education to transform learning environments and personalize instruction is particularly profound. The role of AI in curriculum design across various disciplines and subject matters, supporting AI-related future careers, is among the critical issues educators face today [1].

One area of education that has been extraordinarily affected by intelligent systems is language teaching and learning, as the bridge between computer science, linguistics, and machine learning has enabled the processing and analyzing of large amounts of natural language data and the fabrication and application of sophisticated AI language systems and services [2]. The practical outcomes of AI incorporation in TEFL can be identified in different aspects of language teaching, reshaping the way students learn English and the way teachers consider pedagogical positions. AI-based programs such as chatbots, interactive writing feedback tools, and pronunciation software are designed to respond to the input of individual learners in real time, providing individualized pacing, corrective feedback, and practice matching an individual learner's level of proficiency. Unlike a one-size-fits-all model teaching where students must conform to the group's pace, AI delivers differentiated learning paths, allowing slow learners to have attention and support while advanced learners are kept on their toes all the time, so they do not become uninterested. Over the long term, this responsiveness can mitigate frustration, support the development of learners' confidence, and lead to greater sustained engagement with the learning of a foreign language [3].

Away from the classroom, AI is also making an impact on accessibility and inclusivity in language learning. Students in disadvantaged and poorly equipped areas can still engage with AI-powered platforms to practice language when the classroom is not in session [4]. Similarly, AI tools may be personalized for diverse learner needs, such as students with learning problems and remedial work. Multimodal AI environments that incorporate text, audio, visual cues, and potentially gesture recognition can support various learning styles, making language training more inclusive. Moreover, AI systems might incorporate some gaming features like scoring, ranking, and progress tracking to foster fun and persistent motivation among young learners who can experience fatigue in conventional practice methods. It is also worth mentioning what the contribution of AI can be for the cultivation of learner autonomy. By providing continual, personalized support outside classroom doors, AI enables students to take more ownership over their learning [5].

The use of AI in language learning is transforming the learning process of the students as well as the roles of the teacher for pedagogical practice. Through personalization, inclusivity, and learner autonomy, AI enables more effective, self-directed, and equitable language learning. In this scheme, AI features and affordances offer considerable potential for flipped instruction (FI), where the inverted and innovative teaching procedure demands learners' responsibility to engage in instructional content and higher-order cognitive processing before class sessions. FI has gained prominence as a pedagogical approach that redefines the traditional lecture-based and teacher-centered instruction by engaging students with course content before attending the class session, allowing for more active learning during in-class sessions [6-7]. Rooted in constructivist and learner-centered theories, FI has demonstrated potential for enhancing student engagement, autonomy, and deeper cognitive processing [8]. However, the effectiveness of FI largely depends on the quality, interactivity, and adaptability of pre-class instructional materials [9]. Hence, AI-powered platforms with their potential to transform passive content consumption into dynamic, learner-centered experiences are eminently suitable for content development and delivery. AI tools can facilitate personalized summaries, clarifications, and conceptual explanations based on user queries and enrich FI environments by intelligent tutoring and real-time feedback [10]. While there is growing research on the value of AI-assisted FI in subjects such as science and engineering, the impact of this revolutionary instructional practice in education-related domains remains open to further research. This study thus employs a quasi-experimental design to investigate the effects of AI-assisted FI on the understanding of technical and scientific concepts in the course Psychology of Language Learning. As AI tools can help make complex and intangible ideas more concrete, interactive, and personalized by promoting visualization and simulation, offering data-driven insights, and encouraging critical thinking and deeper understanding, their use in teaching technical concepts of psychology is expected to be fruitful. This gap is noteworthy given that educational psychology courses often involve abstract and complex constructs critical to pedagogical reasoning and professional development in teaching [11]. The study thus aims to answer these questions:

- Does AI-assisted FI have any significant impact on learning scientific concepts as compared to conventional FI and traditional lecture-based instruction?
- Does gender influence learning scientific concepts across different instructional models, that is, AI-assisted FI, conventional FI, and traditional lecture-based instruction

Review of the Related Literature

Theoretical Framework of FI

The flipped classroom, also referred to as flipped instruction (FI), is underpinned by several educational theories that collectively emphasize active learning, learning autonomy, and constructivist engagement. At its core, FI reverses the traditional pedagogical model, where in-class lectures or presentations are followed by out-of-class homework and extensive practice. This is achieved by delivering instructional content outside the class that is typically prepared through videos of the teacher's lectures, followed by classroom tasks that focus on collaborative, interactive, and student-centered activities [12].

The constructivist theory, associated with Piaget and Vygotsky, posits that learners build knowledge actively rather than passively absorbing information, thus changing the role of learners to active agents of learning. FI aligns closely with this view as it facilitates student-led inquiry and problem-solving before the actual teaching, and collaboration and cooperation during face-to-face sessions. This structure supports deeper cognitive engagement as students process, question, and apply content in socially interactive environments [9]. In this framework, Vygotsky's Zone of Proximal Development (ZPD) is operationalized in pre-class materials that provide the initial cognitive scaffolding, allowing classroom time to be used for guided application and peer discussion. In support of how individuals engage with tasks within a community by mediated tools, Activity Theory can also underline FI, emphasizing how technological tools and environments, and structure and patterns of collaboration, shape educational outcomes in a flipped class [13].

FI often increases student self-efficacy and motivation by supporting self-directedness through giving students control and pace of learning when the students interact with the content before the class instruction. Self-Determination Theory underscores this type of learning when the interplay among autonomy, competence, and relatedness needs fosters intrinsic motivation for learning. Autonomy is developed and enhanced when students access the instructional content outside of the class at their own pace, time, and even knowledge. The students' sense of competence and mastery is often supported by interactive activities in class sessions when students focus on problem-solving skills, discussion, and application of their knowledge. Relatedness is also backed during collaboration in the class when the interaction between the peers and/or teacher-peer interaction is meaningful, as everybody tries to be a part of the learning experience [14].

FI also aligns well with cognitivism as Bloom's taxonomy of cognitive processing underpins the design and implementation of flipped classes. In FI, the traditional cognitive engagement structure is reversed, where the lower-order thinking skills are addressed before the class and the higher-order thinking skills are developed during class. Usually, the two lower-order thinking skills, that is, remembering and understanding, are done out of class so that the students can develop foundational knowledge on the matter. Then, classroom time is consumed by active and collaborative learning tasks to promote students' critical and creative thinking. Thus, tasks that demand applying, analyzing, evaluating, and creating based on the learned topics are done in the class phase [15]. Notably, FI aligns with Cognitive Load Theory (CLT) by allowing students to manage intrinsic and extraneous loads more effectively by engaging with complex topics at their own pace and preference outside the class. As most videos are interactive, the students can watch and rewatch the teacher's lecture and thus feel less mentally bothered than they do in single-shot classroom teachings [16].

AI-assisted FI

Although the flipped approach is "a pedagogical change and not a technological one" [17, p. 1], technology plays a key role in designing teaching materials and delivering instructional practice in FI. As extensive research on educational technology illustrates, technology is a delivery channel that fosters developing and sharing instructional content and facilitates student-centered learning, leading to better learning gains in many subjects. The technologies that are used to prepare FI instructional content can be classified into low-tech, mid-tech, and high-tech based on three basic criteria that is teacher IT literacy and access, the need for programming knowledge, and the presence of Intelligent Tutoring Systems (ITS) [18].

Teachers can use simple technological devices/environments to prepare and deliver the content to students. The conventional FI class that dominates the literature [19] consists of teacher's PowerPoint files with voiceovers that are shared with students via social media or cloud services. Mid-tech systems such as LMSs or streaming platforms are often online modules that can be used as they are or are tailored to the needs of the class by adjusting the system's features. High-tech systems have not been very prevalent in FI before users' widespread access to AI services and tools. The intelligent systems are capable of making smart decisions about strategies of tutoring/learning and thus are ideal tools for personalization of instruction, without disregarding mastery of critical skills and knowledge [18].

AI, defined as "the development of systems that can simulate, augment, or replace human cognitive functions …. through algorithmic and data-driven models capable of improving autonomously over time" [20], can revolutionize FI, enhancing both the pre-class and in-class learning experiences. Ray and Sikdar remarked that AI tools can be integrated into FI for personalized learning paths, adaptive assessments, content curation and recommendation, virtual tutoring and support, and data analytics for educators [21]. They also noted the potential of AI-assisted FI to enhance engagement, improve learning outcomes, use class time effectively, enhance educational equity, and contribute to teachers' professional empowerment.

Recently, a body of research has been done to elucidate the potential of implementing AI tools to flip the instruction. In their review on the impacts of AI-chatbots in FI, Low and Hew reported certain merits for AI-assisted FI, including improvement of class preparation, increased student interaction with learning content, and implementation of data-driven teaching and learning [22]. Katona and Gyonyoru showed that implementing AI-based adaptive feedback in FI leads to significant improvements in learning outcomes and motivation, as well as an increase in student autonomy that caused more collaboration and participation in class sessions [23]. Similarly, Chu et al. illustrated a significant impact of AI-assisted FI to improve learning outcomes as well as increased interaction and engagement in class participation [24]. Li and Peng's study demonstrated that AI-assisted FI can generate more positive attitudes to learning experiences in regard to interest, study skills, and class participation. Integrating AI into FI lowered mental processing loads and boosted students' confidence by lowering their anxiety about class interaction [25]. Hu's study showed that integrating a generative AI into FI not only prevents autonomous mental task load but also maintains students' pre-class preparation and enhances confidence in ethical learning [26]. Chen et al. illustrated that AI-generated virtual instructors of FI can significantly enhance affective engagement and academic performance and lower cognitive load compared to the human instructor [27]. Silitonga et al. reported that AI-assisted FI was influential in boosting motivation and higher-order thinking, including creativity, critical thinking, and problem-solving [28]. Jayaraman and Kolarkar found that AI-assisted FI not only increases student engagement and achievement but also decreases course withdrawals by 18.5% [29].

Despite the positive findings of these studies, certain limitations and potential challenges for flipping instruction with AI tools and services are pinpointed. Aligning teaching objectives with AI techniques, ethical considerations, and human-computer interaction should be carefully observed to ensure the successful use of AI in FI [30]. Equity and access to AI, privacy and data security, students' low motivation [21], and teachers' empowerment to use new technologies [31] as well as AI's limited technical functionality and lack of authenticity are among other challenges of AI-assisted FI that demand more examination of the impact of AI generative on learning gains in various educational contexts [22].

AI-assisted FI and Language Learning

The integration of AI into the FI model can impact course design and instructional practices to create more adaptive, personalized, and data-informed learning environments for language learners. The confluence of AI and FI in language curriculum affects both cognitive and affective domains of language acquisition by promoting engagement, self-regulation, and communicative competence [18].

AI-driven systems are increasingly used to personalize pre-class language learning modules, particularly in listening, speaking, and grammar-oriented content. Rahmawati and Fitriati, for instance, introduced a four-strand approach integrating AI-assisted pre-class modules in adaptive listening tasks and pronunciation feedback systems. Results suggested that AI-facilitated software improved access to input, language accuracy, and learner engagement, but drawbacks related to contextual appropriacy, reliability of feedback, and continuity of pedagogy also arose [16]. In another study, Choudhary et al. documented improvement of oral proficiency among EFL learners within an AI-enhanced FI environment. Tools such as speech recognition engines, accent analyzers, and grammar checkers allowed for autonomous improvement before class sessions [32]. Ouahmiche and Bouguebs explored the intersection of AI, flipped learning, and intercultural competence and argued that AI can simulate cross-cultural communication scenarios and enable learners to practice real-world interaction in safe, controlled environments [34]. Namaziandost reported that AI-enhanced FI significantly improved EFL learners' metacognitive awareness, promoted their writing development, and reduced boredom [28]. Phanwiriyarat et al. explored the impact of an AI-powered gamified flipped classroom in an English-speaking course and reported significant improvements in speaking skills, particularly in topic communication and discussions, with students reporting increased confidence in casual conversations and presentations [35].

A limited number of studies have also focused on exploring the influence of AI-assisted FI in understanding scientific topics in the language curriculum. Chan and Liu implemented a GenAI-supported pronunciation model that provided real-time feedback on scientific and academic terms, improving learners' oral academic discourse skills, which is a crucial asset for language educators in training [35]. In another study, Reinders et al. documented how Korean language teacher candidates trained with AI-assisted FI tools developed an improved understanding of content-language integrated learning frameworks and were more confident in explaining scientific terms [37]. The synopsis of literature shows that, while the innovative model of AI-assisted FI is more extensively used in STEM education [38], its potential for teaching and learning scientific concepts, particularly in social sciences and language education, is unexplored.

Method

Participants

The participants included three groups of BA students who enrolled in the course Psychology of Language Learning I (n=73). The students' major was Teaching English as a Foreign Language (TEFL). The sample included 32 male (44%) and 41 female (56%) students. They ranged in age between 20-23 (Mean=20.24). None of the students had passed any course in Psychology of Language Learning, and they were not familiar with the scientific concepts of the course. The participants were randomly assigned to be of three groups: Group 1 (n=26) received AI-assisted FI, Group 2 (n=25) received conventional FI, and Group 3 (n=22) received a lecture-based instructional.

All participants were fully informed about the purpose of the study, including the use of NotebookLM in instruction. Participation was voluntary, and AI was only used as an assistive tool under human supervision. The study adhered to ethical guidelines for educational research and AI ethics, ensuring fairness, transparency, accountability, and respect for human dignity.

Instruments

Two researcher-made knowledge tests were developed to assess the participants' understanding of the topics presented in the course by midterm and final exams. The questions were designed considering Bloom's hierarchy of cognitive processing, including remembering, understanding, applying, analysing, evaluating, and creating.

Each test had 25 explanatory items organized into two sections. Questions that assessed students' remembering and understanding were organized in section 1, Theory, and questions that assessed students' ability to apply what they learned, analyze problems, evaluate the scenarios, and create materials were put in section 2, Practice.

Both tests had been piloted in previous courses with samples similar to the current study's participants (N=44). The content validity of the test was assessed by three TEFL instructors who reviewed the items based on the accuracy of the information presented, clarity of the language, and correspondence between the number of items and the syllabus of the course and the discussed topics. Based on the received feedback, the format and wording of a few items were revised.

All papers were corrected twice, with a time interval of 2 weeks, by the instructor using an analytical rubric. The intra-rater reliability was found to be 0.92.

Teaching Materials

The course Psychology of Language Learning I is a 2-unit theoretical course in the curriculum of the BA of English Language Teaching approved by Iran's Ministry of Science, Technology, and Research [39]. The objectives of the course include the history and frameworks of language learning psychology and their components (e.g., affect, motivation, memory, intelligence, etc.). The main textbook of the course was Exploring Psychology in Language Learning and Teaching [40]; however, a variety of sources were used to prepare and deliver instructional content and lectures.

AI Platform

NotebookLM (notebooklm.google.com) was used to prepare the instructional content for the AI-assisted FI group. NotebookLM is an AI-powered research and study tool developed by Google, designed to support learners and professionals in synthesizing information across multiple sources. Functioning as a personalized knowledge assistant, NotebookLM allows users to upload documents-such as PDFs, lecture notes, or web content, based on which it generates summaries, concept maps, definitions, and contextual explanations through natural language interaction [41].

One of the tool's distinguishing features is its 'Discovery Window', which automatically identifies key ideas, organizes core concepts, and surfaces thematic relationships among documents. This function facilitates deep learning by enabling users to engage with source material in a structured, inquiry-based manner. Users can also prompt the system with specific questions, generate outlines, or explore thematic 'deep dives', which are customized narratives derived from uploaded content (Fig. 1).

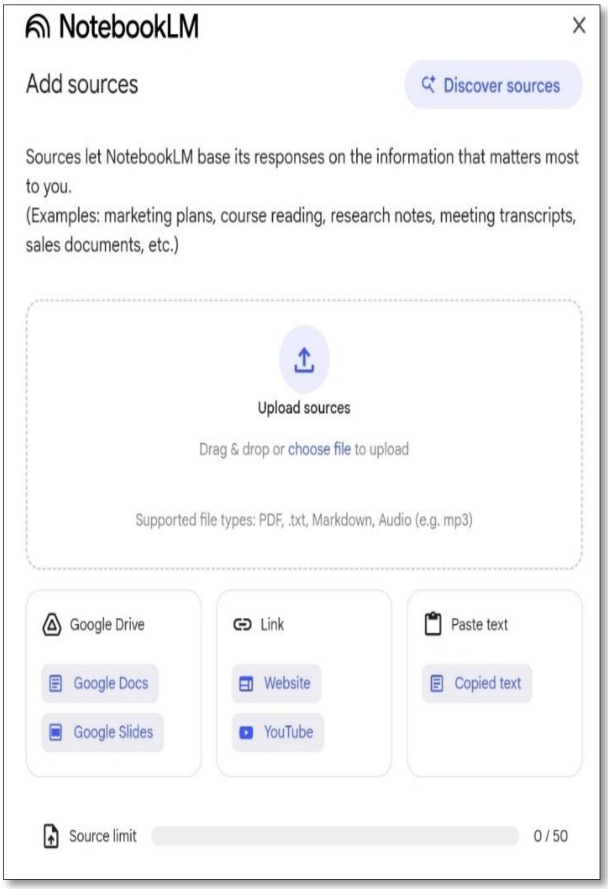

Fig. 1: NotebookLM (notebooklm.google.com)

From a pedagogical perspective, NotebookLM aligns with contemporary constructivist and cognitive learning theories, particularly in its support for metacognition, conceptual mapping, and personalized feedback. NotebookLM has begun to gain attraction in educational research, especially in exploring AI tools for teaching and learning, and engaging learners with the content. Therefore, it was considered a suitable tool for AI-enhanced FI as a core element to prepare content for Group 1. Deep dives generated through NotebookLM served as pre-class instructional materials, replacing traditional reading or lecture content. These materials included synthesized topic overviews, mind maps, and audio recordings based on AI-curated knowledge paths, all of which were reviewed and refined by the instructor of the course to ensure conceptual accuracy and pedagogical soundness.

Procedure

Three groups of BA students enrolled in the Psychology of Language Learning course were channeled into three types of instruction. They received instruction based on three teaching models for one semester that lasted for 17 weeks. The class met once a week and each session lasted 90 minutes. The midterm exam was held in session 8. The final exam was held two weeks after session 17. The instructional models for each group are detailed below and summarized in Table 1.

AI-assisted FI Group

The AI-assisted FI group received a flipped class following the standard procedure of pre-class, in-class, and post-class phases that were designed based on AI tool affordances.

Table 1: Instructional Models for the Context of the Current Study

Components	AI-assisted FI	Conventional FI	Lecture-based instruction
Pre-class content	AI-generated deep dives (audio, notes, mind maps)	Instructor voiceover slides (PowerPoint presentations)	None
In-class activities	Review, group/pair activities, summary writing, or oral talk	Review, group/pair activities, summary writing, or oral talk	Lecture followed by Q&A
Post-class tasks	Summarizing, worksheet completion, and optional continued AI use	Summarizing or worksheet completion	Not formally assigned (students advised to review the textbook
Interaction pattern	Collaborative, AI-enhanced	Collaborative, non-AI	Primarily instructor-led

Pre-class Phase

A total of 22 deep dives were developed on the official syllabus of the Psychology of Language Learning course. Each deep dive was designed to introduce, elaborate, and reinforce key theoretical and conceptual components of the course content in alignment with FI principles.

The deep dives were created using NotebookLM based on prompts developed by the instructor to target core concepts outlined in each weekly topic. The platform's Discovery Window was employed to gather and organize relevant excerpts, definitions, and frameworks. All AI-generated outputs were refined and curated by the instructor to ensure conceptual accuracy, academic reliability, and alignment with instructional goals and objectives. Each deep dive module included a podcast-style audio file, ranging in length from approximately 3.5 to 5 minutes. The audio content featured a scripted conversation between a male and female speaker, both using a standard American English accent. The podcast structure was consistent across episodes: it began with an introduction of the topic, followed by conceptual expansion, and concluded with a summary of reflective questions to encourage critical thinking. Some episodes included open-ended questions designed to stimulate further inquiry and class discussion. In addition to the audio files, each deep dive package included key summary notes, mind mapping to visualize the relationships between subtopics and concepts, and links or prompts for further exploration.

Group 1 was encouraged to interact with the AI tools independently (e.g., generating follow-up questions, using mind maps for revision) to deepen their understanding of the content. These structured pre-class materials replaced traditional readings and were made available through the university's learning management system (LMS) before in-class sessions. The procedure thus embedded AI as both content generator and cognitive scaffold, aligning with principles of technology-enhanced learning and FI models [13-15].

In-class Phase

Each class session began with a brief knowledge check to assess student engagement with the pre-class materials, mainly the deep dives. This was achieved through mini quizzes, oral discussions, or question-and-answer exchanges. When necessary, key podcast segments were replayed in class to reinforce understanding or clarify misconceptions.

Following the knowledge check, students participated in pair or small-group activities that required them to apply, extend, or reflect on the concepts introduced during the AI-generated deep dives. Activities included completing structured task sheets or worksheets, analyzing sample classroom interactions, or generating examples relevant to the applications of psychological concepts/theories in language teaching/learning. These collaborative tasks encouraged peer dialogue and co-construction of knowledge, aligning with constructivist principles and interactive goals of FI [17].

Subsequently, each group or pair was invited to share their interpretations or responses with the whole class, either through brief oral presentations or guided discussions. This sharing phase allowed for diverse perspectives to emerge and provided opportunities for clarification, debate, and instructor feedback.

The final part of the session focused on individually synthesized outputs, such as summary writing tasks, reflective notes, or brief spoken reports that helped students consolidate their learning. The activities also supported the development of key academic and communication skills relevant to their future roles as EFL teachers.

Post-class Phase

After class, students were assigned follow-up tasks intended to reinforce learning and extend the in-class experience. These included writing summaries, completing additional sections of the worksheet, or interacting further with AI tools to explore unanswered questions or related topics. The structured post-class tasks ensured continuous engagement and helped prepare students for subsequent sessions.

Conventional FI Group

The students of Group 2 received conventional FI designed and implemented in three phases of pre-class, in-class, and post-class sessions.

Pre-class Phase

The pre-class materials for this group were in the form of PowerPoint presentations with embedded voiceovers, created and narrated by the course instructor. These materials were designed to present the core content of each weekly topic as outlined in the course syllabus. The voiceovers aimed to simulate lecture delivery and provided explanations, examples, and guiding questions to support student comprehension.

Unlike the AI-assisted group, students of the conventional FI did not interact with AI tools. Their pre-class preparation was instructor-led, limited to viewing the narrated slides independently before the class session.

In-class Phase

The in-class sessions followed a structure similar to that of the AI-assisted FI group to maintain instructional consistency across groups. Each session included a brief review activity, optional replay of selected voiceover segments, group/pair work, whole-class sharing and instructor feedback, and a final summary writing task or oral report. No instructional AI tools were embedded in the teaching/learning process of this group. Instead, all guidance and content scaffolding were provided by the instructor or through the voiceover slides.

Post-class Phase

Post-class tasks included summarizing key points, completing worksheets, and preparing for upcoming sessions.

Lecture-based Instruction

Group 3 received content through lecture-based delivery, following a teacher-centered model. Unlike the FI groups, students in this condition did not engage with any pre-class materials. Instructional content was presented in class through live lectures conducted by the instructor, supported by textbook chapters and PowerPoint slides.

The majority of the time of the session was dedicated to the direct transmission of course content. The instructor explained key concepts, provided examples, and occasionally asked questions to promote brief student participation. However, there was no structured group or pair work, worksheets, or AI-based exploration tasks. The final 15-20 minutes of each session were allocated to a question-and-answer segment, where students could seek clarification or revisit complex ideas discussed during the lecture.

This group was not assigned any structured post-class tasks. They were instead encouraged to review the textbook chapters covered during the lecture.

Results and Findings

A two-way Multivariate Analysis of Anova (MANOVA) was used to compare the groups' learning gains in the course. In this analysis, types of instruction (AI-assisted FI, conventional FI, and lecture-based instruction) and gender (male and female) served as the independent variables, and knowledge test scores (midterm and final exams) were the dependent variables. Before running the MANOVA, preliminary assumption testing was conducted to check for normality, linearity, and univariate and multivariate outliers [42]. Homogeneity of variance-covariance matrices was assessed by Box's M Test of Equality of Covariance Matrices (Table 2), implying that the observed covariance matrices of the dependent variables were equal across groups.

Table 2: Box's Test of Equality of Covariance Matrices

Box's M	23.199
F	1.419
df1	15
df2	13216.594
Sig.	0.128

The result of Multivariate Tests for the first main effect, that is the impact of intervention on learning outcomes, revealed a significant difference between three groups on the combined dependent variables [Wilks' Lambda=0.473; F (4, 132) = 14.966; p=0.000<0.001] with a large effect size (ηp^2=0.312> 0.14) based on Cohen's guideline [43]. The large effect size suggests that the intervention had a meaningful impact on students' learning gains and can explain over 30% of the improvement in participants' performance. Before examining Tests of Between-Subjects effects, Levene's test of Equality of Error Variances was checked (Table 3), showing that the assumption of equality of variance for dependent variables was not violated.

Table 3: Levene's Test of Equality of Error Variances

	Levene Statistic	df1	df2	Sig.
Midterm Exam	0.116	5	67	0.988
Final Exam	1.358	5	67	0.251

Tests of Between-Subjects Effects were then examined, and as the results for the dependent variables separately (midterm and final exam) showed, both differences reached statistical significance (Table 4). Both effects were strong (ηp^2=0.478 and ηp^2=0426, respectively), implying that the intervention had a strong effect in enhancing students' understanding of technical and scientific concepts, as measured by both midterm and final exams.

Post hoc comparisons using Tukey's HSD test and descriptive statistics (Table 5) revealed that students in Group 1 scored significantly higher than those in Groups 2 and 3 in midterm and final exams. Additionally, Group 2 performed significantly better than Group 3 in midterm and final exams, confirming a hierarchy of instructional effectiveness, with AI-assisted FI yielding the highest gains in conceptual understanding.

The result of Multivariate Tests for the second main effect, that is, gender, [Wilks' Lambda=0.975; F (2, 66) = 0.836; *p*=0.438>0.001] and the interaction effect between gender and instructional method [Wilks' Lambda=0.963; F (4, 132) = 0.628; *p*=0.644>0.001] were not statistically significant. This implies that the observed differences in achievement across groups were not moderated by gender.

Table 4: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Midterm	1489.871[a]	5	297.974	12.991	0.000	0.492
	Final	1871.593[b]	5	374.319	11.335	0.000	0.458
Intercept	Midterm	18001.869	1	18001.869	784.868	0.000	0.921
	Final	24420.706	1	24420.706	739.478	0.000	0.917
Group	Midterm	1404.989	2	702.494	30.628	0.000**	0.478
	Final	1641.705	2	820.853	24.856	0.000**	0.426
gender	Midterm	12.789	1	12.789	0.558	0.458	0.008
	Final	9.699	1	9.699	0.294	0.590	0.004
Group * gender	Midterm	44.120	2	22.060	0.962	0.387	0.028
	Final	62.506	2	31.253	0.946	0.393	0.027
Error	Midterm	1536.724	67	22.936			
	Final	2212.626	67	33.024			
Total	Midterm	22351.938	73				
	Final	30494.250	73				
Corrected Total	Midterm	3026.594	72				
	Final	4084.219	72				

a. R Squared = .492 (Adjusted R Squared = 0.454)

b. R Squared = .458 (Adjusted R Squared =0 .418)

Table 5: Descriptive Statistics of Midterm and Final Exams across Three Groups

	Group	Mean	SD
Midterm Exam	AI-assisted FI	21.653	5.001
	Conventional FI	15.500	4.658
	Lecture-based	10.784	4.628
Final Exam	AI-assisted FI	25.221	5.016
	Conventional FI	17.750	6.440
	Lecture-based	13.136	5.596

The outcome showed a significant difference between the groups' achievement in the course, but not across genders, illustrating how AI can support more inclusive, accessible, and fair learning opportunities when the students benefit from equitable participation and access to the instructional content.

Discussion

The findings of this study confirm that integrating AI-assisted FI significantly enhances students' conceptual understanding, particularly in domains requiring a deep understanding of theoretical constructs, such as language learning psychology. Students in the AI-powered group significantly outperformed those in both conventional FI and traditional lecture-based formats, as measured by midterm and final exams.

What differentiates the instruction AI-assisted group received in this study is the use of NotebookLM deep dive synthesis feature, which allowed for tailored, multisource learning materials that emphasized coherence, explanation, and conceptual linkage. Unlike slides used in conventional FI models, the deep dives presented content as dynamically structured knowledge, offering students the opportunity to engage in personalized, self-paced learning with materials curated around course objectives. This method likely supported higher-order thinking skills, such as application, analysis, evaluation, and creation, which is backed by the fundamentals of FI [13-14]. Intelligence systems, particularly those driven by AI, transform the educational landscape as they enable adaptive learning by tailoring content delivery to individual learners' needs, thereby supporting differentiated instruction and promoting personalized learning pathways [45]. Recent research has demonstrated that AI-driven platforms can enhance learner engagement and motivation by offering context-sensitive feedback, interactive interfaces, and real-time scaffolding [46]. Moreover, intelligent educational systems facilitate data-informed instruction, allowing educators to track progress, predict learning gaps, and adjust strategies accordingly [47].

Particularly, the intelligent systems powered by AI tools are proving highly effective in supporting abstract and theory-driven learning, particularly in higher education. Abstract and theoretical content often challenge learners' working memory and conceptual understanding. Intelligent systems can mediate this by adapting instructional materials to learners' cognitive profiles, using interactive simulations, visualizations, and generative explanations that concretize abstract principles [48]. Moreover, the dialogic affordances of AI, such as question-answering, conceptual summarization, and semantic expansion, mirror Socratic pedagogies known to deepen theoretical understanding in FI [49]. These systems can also serve as cognitive scaffolds, aiding learners in constructing and refining mental models of abstract domains through repeated interaction, feedback, and reflection [50].

The study's outcomes are consistent with research emphasizing that AI tools can enhance learning by supporting adaptive content delivery and reducing cognitive load [44]. The pre-class AI materials likely acted as cognitive scaffolds, which, according to discovery learning theory, provided structured support that enabled students to reach higher levels of understanding than they could independently [28][51]. The AI-generated content not only summarized course materials, but also synthesized connections between key terms and concepts aligned with constructivist learning principles, wherein students construct meaning from active engagement with contextually rich material [26][52].

Importantly, the lack of gender differences in performance across instructional groups suggests that AI-powered instruction may foster a more equitable learning environment. Traditional instruction can sometimes perpetuate performance gaps rooted in different access to engagement or instructor bias. However, by delivering uniform on-demand and bias-free instructional materials, AI tools may help neutralize demographic disparities, offering all learners-regardless of their gender-access to high-quality, scaffolded support [53]. This finding supports prior evidence that personalized learning environments, when designed equitably, can minimize demographic performance gaps and promote inclusivity in education [54]. The equal benefit across gender implies that AI-assisted FI is not only pedagogically effective but also socially responsive, aligning with the goals of inclusive teaching [55-56].

Conclusions

This study demonstrates the instructional value of integrating AI-assisted FI in higher education, particularly when enhanced by structured, personalized content such as NotebookLM's deep dives. The AI group not only achieved higher performance on assessments but did so consistently across gender, indicating the equitable potential of AI-powered instructional design. By enabling deeper cognitive engagement and mitigating disparities through personalized, bias-free pre-class materials, AI-assisted FI instruction emerges as both a pedagogically sound and socially appropriate educational strategy.

Nonetheless, this study is not without limitations. The sample size was modest, and the study was limited to one institution and one subject area. Furthermore, the study lasted for one semester, and delayed evaluation of learning gains was not possible. Future research should examine the use of AI-generated deep dives across disciplines and academic contexts, incorporate qualitative feedback from students, and explore the longitudinal effects of AI-assisted instruction on academic development and skills mastery.

The findings hold critical implications for MOE, particularly in the context of EFL teacher preparation programs. As future educators, pre-service teachers need exposure to innovative instructional models that reflect 21st-century teaching realities. MOE is responsible for national teacher training standards and thus should consider formally integrating AI-supported instruction into the EFL curriculum, preparing teachers not only to teach language, but to teach with technology.

For higher education institutions, these results suggest that reimagining education through AI-enhanced instructional models can improve instructional efficacy and learner autonomy. Educators are encouraged to transition from content delivery to facilitation of professional skill development, guaranteeing lifelong learning through curriculum change.

Finally, for EdTech developers and policy advisors, this study signals the need to design AI tools that are context-sensitive, multilingual, and aligned with educational policy objectives in language learning and EFL teacher education. AI platforms should offer scalable support for diverse linguistic, cultural, and pedagogical contexts, while also promoting ethical AI use and data privacy within national systems.

Authors' Contribution

Author 1 conceptualized, designed, and supervised the research, and drafted, wrote, reviewed, and edited the manuscript. Author 2 gathered the data and helped in writing the manuscript. Both authors have read the article

and approved the submitted version. The authors'

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Conflicts of Interest

The authors have no conflicts of interest.

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ORIGINAL RESEARCH PAPER

Exploring Iranian University Students' Expectations and Technology Use for Out-of-Class English Language Learning

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ABSTRACT

Background and Objectives: This study examines the expectations and actual use of technology by Iranian university students for out-of-class English as a Foreign Language (EFL) learning. It explores the factors influencing technology use, barriers encountered, and students' recommendations for enhancing technology-driven language learning. The research aims to provide insights into how students adapt to technological barriers in Iran, such as internet filtering, high costs, and low-speed connections. The study is guided by the Technology Acceptance Model (TAM) and Expectation-Disconfirmation Theory (EDT), which posit that satisfaction arises when actual experiences meet or exceed expectations.

Materials and Methods: Using a sequential exploratory mixed-methods design, the study consisted of both qualitative and quantitative phases. The qualitative phase involved semi-structured interviews with 24 senior English students (11 males, 13 females), while the quantitative phase included a survey of 48 undergraduate TEFL and English Literature students (7 males, 41 females). The research was conducted during the 2024–2025 academic year.

Findings: Students were generally satisfied with their technology use for language learning, as their actual experiences closely aligned with their expectations. Despite infrastructural and political constraints, such as low internet speed, filtering of websites requiring VPNs, and high costs, students demonstrated resilience and resourcefulness in utilizing digital tools for language acquisition. Key factors influencing technology use included time flexibility, accessibility, cost efficiency, and teacher support. However, students reported significant challenges, including lack of teacher guidance and distractions associated with technology use. Quantitative analysis revealed no significant differences between students' expectations and their actual use of technology. Additionally, there were no notable gender-based differences in either expectations or usage patterns, indicating that male and female students face similar challenges and opportunities. These findings align with TAM and EDT, suggesting that students' satisfaction arises from the alignment between their expectations and actual experiences. Students emphasized the importance of teacher guidance in improving the effectiveness of technology use, highlighting the need for educators to provide direction on selecting appropriate tools and strategies. They proposed practical recommendations, including reducing internet filtering, incorporating gamified learning tools, establishing consistent study routines, and focusing on high-quality resources to optimize their learning experiences.

Conclusions: This study underscores the critical role of technology in facilitating out-of-class EFL learning in restrictive contexts like Iran. It highlights students' ability to overcome challenges, leveraging available resources for language acquisition. Policymakers are encouraged to reconsider restrictive measures, such as internet filtering, as students have demonstrated responsible and effective use of technology for educational purposes. Teachers are urged to guide students in utilizing technology more effectively, ensuring personalized and structured learning experiences. Despite its contributions, the study faced limitations, including a small sample size restricted to English-major students at two universities, which may limit the generalizability of findings. Future research should expand to include students from diverse academic disciplines, educational levels, and geographical regions. Incorporating teacher perspectives and conducting comparative studies across different cultural contexts would provide a more comprehensive understanding of technology's role in EFL learning. By addressing barriers and leveraging teacher support, this study highlights how technology can further enhance autonomous learning experiences. Policymakers and educators are encouraged to foster a more supportive environment for technology integration, ensuring equitable and effective access to digital resources for all learners.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
37	1	9

مقاله پژوهشی

بررسی انتظارات دانشجویان دانشگاه‌های ایران و استفاده از فناوری برای یادگیری زبان انگلیسی خارج از کلاس

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واژگان کلیدی:
دانشجویان دانشگاه
استفاده واقعی از فناوری
انتظارات
یادگیری زبان انگلیسی به عنوان زبان خارجی

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چکیده

پیشینه و اهداف: این مطالعه به بررسی انتظارات و استفاده واقعی دانشجویان دانشگاه‌های ایران از فناوری برای یادگیری زبان انگلیسی به‌عنوان زبان خارجی (EFL) در خارج از کلاس می‌پردازد. این پژوهش عواملی که بر استفاده از فناوری تأثیر می‌گذارند، موانع موجود و پیشنهادات دانشجویان برای بهبود یادگیری زبان مبتنی بر فناوری را بررسی می‌کند. هدف این تحقیق ارائه بینشی درباره نحوه تطبیق دانشجویان با موانع فناوری در ایران، مانند فیلترینگ اینترنت، هزینه‌های بالا و سرعت پایین اینترنت است. این مطالعه بر اساس "مدل پذیرش فناوری (TAM) "و "نظریه انتظار-ناهمخوانی (EDT) "انجام شده است که بیان می‌کنند رضایت زمانی حاصل می‌شود که تجربیات واقعی با انتظارات برابر یا فراتر از آن باشند.

روش‌ها: این مطالعه با استفاده از طرح ترکیبی اکتشافی متوالی انجام شد و شامل دو مرحله کیفی و کمی بود. مرحله کیفی شامل مصاحبه‌های نیمه‌ساختاریافته با ۲۴ دانشجوی سال آخر رشته زبان انگلیسی (۱۱ مرد و ۱۳ زن) بود. در مرحله کمی، از ۴۸ دانشجوی کارشناسی رشته‌های آموزش زبان انگلیسی (TEFL) و ادبیات انگلیسی (۷ مرد و ۴۱ زن) نظرسنجی شد. این پژوهش در سال تحصیلی ۲۰۲۴–۲۰۲۵ انجام گرفت.

یافته‌ها: دانشجویان عموماً از استفاده خود از فناوری برای یادگیری زبان رضایت داشتند، زیرا تجربیات واقعی آن‌ها به‌طور کلی با انتظاراتشان مطابقت داشت. با وجود محدودیت‌های زیرساختی و سیاسی، مانند سرعت پایین اینترنت، فیلترینگ سایت‌ها که نیاز به استفاده از VPN داشتند و هزینه‌های بالا، دانشجویان انعطاف‌پذیری و خلاقیت خود را در استفاده از ابزارهای دیجیتال برای یادگیری زبان نشان دادند. عوامل کلیدی تأثیرگذار بر استفاده از فناوری شامل انعطاف‌پذیری زمانی، دسترسی‌پذیری، مقرون‌به‌صرفه بودن و حمایت معلمان بود. با این حال، چالش‌های مهمی مانند نبود راهنمایی معلمان و حواس‌پرتی ناشی از استفاده گسترده از فناوری گزارش شد. تحلیل کمی نشان داد که بین انتظارات دانشجویان و استفاده واقعی آن‌ها از فناوری تفاوت معناداری وجود ندارد. علاوه بر این، تفاوت قابل توجهی بین انتظارات و الگوهای استفاده دانشجویان زن و مرد مشاهده نشد که نشان می‌دهد دانشجویان زن و مرد با چالش‌ها و فرصت‌های مشابهی مواجه هستند. این یافته‌ها با مدل TAM و نظریه EDT همخوانی داشت و نشان داد که رضایت دانشجویان از هماهنگی بین انتظارات و تجربیات واقعی ناشی می‌شود. دانشجویان بر اهمیت راهنمایی معلمان برای بهبود اثربخشی استفاده از فناوری تأکید کردند و نیاز به جهت‌دهی معلمان در انتخاب ابزارها و استراتژی‌های مناسب را برجسته کردند. آن‌ها پیشنهاداتی عملی ارائه کردند، از جمله کاهش فیلترینگ اینترنت، استفاده از ابزارهای یادگیری بازی‌محور، ایجاد روال‌های مطالعه منظم و تمرکز بر منابع باکیفیت برای بهینه‌سازی تجربیات یادگیری خود.

نتیجه‌گیری: این مطالعه نقش حیاتی فناوری در تسهیل یادگیری زبان انگلیسی در خارج از کلاس، به‌ویژه در زمینه‌های محدودکننده‌ای مانند ایران را برجسته می‌کند. این مطالعه توانایی دانشجویان در غلبه بر چالش‌ها و استفاده بهینه از منابع موجود برای یادگیری زبان را نشان می‌دهد. از سیاست‌گذاران خواسته می‌شود تا محدودیت‌هایی مانند فیلترینگ اینترنت را بازنگری کنند، زیرا دانشجویان استفاده مسئولانه و مؤثر خود از فناوری برای اهداف آموزشی را نشان داده‌اند. همچنین از معلمان خواسته می‌شود تا دانشجویان را در استفاده مؤثرتر از فناوری راهنمایی کنند و تجربه‌های یادگیری شخصی‌سازی‌شده و ساختارمندتری را ارائه دهند.

علی‌رغم دستاوردهای این مطالعه، محدودیت‌هایی مانند اندازه نمونه کوچک که به دانشجویان رشته زبان انگلیسی در دو دانشگاه محدود می‌شد، ممکن است قابلیت تعمیم یافته‌ها را کاهش دهد. تحقیقات آینده باید دامنه خود را گسترش دهد و شامل دانشجویان از رشته‌های دانشگاهی، سطوح تحصیلی و مناطق جغرافیایی مختلف شود. همچنین، گنجاندن دیدگاه معلمان و انجام مطالعات مقایسه‌ای در زمینه‌های فرهنگی مختلف می‌تواند درک جامع‌تری از نقش فناوری در یادگیری زبان انگلیسی به‌عنوان زبان خارجی ارائه دهد. با غلبه بر موانع و استفاده از حمایت معلمان، این مطالعه نشان می‌دهد که چگونه فناوری می‌تواند تجربیات یادگیری خودمختار را تقویت کند. سیاست‌گذاران و مربیان تشویق می‌شوند تا محیطی حمایتی‌تر برای ادغام فناوری فراهم کنند و دسترسی عادلانه و مؤثر به منابع دیجیتال را برای همه زبان‌آموزان تضمین کنند.

Introduction

In today's fast-evolving world, students' learning styles, expectations, and educational needs are in constant flux. Each generation brings with it unique characteristics shaped by interactions with teachers, classroom dynamics, technology, and other educational resources. Staying current with these shifts is essential for maintaining and improving educational quality [1]. In particular, language education has experienced significant transformation over recent years, and the COVID-19 pandemic further underscored the critical role of technology in language learning, accelerating the adoption of digital tools and remote learning practices [2]. These developments highlight the ongoing need to evaluate and adapt educational strategies to align with the changing landscape, ensuring that students' needs are effectively met in an increasingly digital environment.

Technology has become a core component of language education, fundamentally changing how students approach learning by enabling self-directed study outside the traditional classroom [3, 4]. With the advent of digital platforms, students increasingly rely on technology to facilitate independent learning, making education more accessible across diverse socioeconomic and geographic backgrounds [5]. This shift towards autonomous learning is especially beneficial as traditional classroom environments often struggle to meet the needs of students with varying backgrounds, learning styles, and language proficiencies [6]. Research indicates that out-of-class learning, when supported by technology, can supplement in-class instruction and positively impact language proficiency [7]. However, to fully realize these benefits, ensuring the quality of out-of-class learning experiences is paramount [8]. As such, the integration of technology must be approached with a focus on inclusivity, quality, and the development of resources that cater to diverse learner needs.

Autonomy, or students' ability to direct their own learning, is often enhanced through the effective use of technology. Teachers play a crucial role in guiding students on how to use these resources effectively, helping foster independence while providing necessary support [9]. Social media, educational apps, and other digital platforms allow students to personalize their language learning experiences based on their individual preferences and needs. However, excessive or unstructured use of such technology can lead to challenges, such as reduced face-to-face social interaction, potential distractions, and disruptions to sleep patterns [10]. Therefore, a balanced approach is essential, where technology is used to complement, rather than replace, meaningful human interactions and structured learning environments.

In this study, "actual use of technology" refers to the self-reported frequency and ways in which students utilize technology for language learning, while "technology expectations" represent students' beliefs about how extensively and effectively technology should be incorporated into their studies [11]. Drawing on Expectation-Disconfirmation Theory (EDT), this study considers expectations as students' anticipated performance of specific technologies, with satisfaction dependent on whether these expectations are met or exceeded [12, 13]. This framework provides a valuable lens through which to understand the interplay between students' perceptions and their actual experiences, offering insights that can guide educators and policymakers in optimizing technology use.

For the purposes of this research, technology is defined under the umbrella of "Technology-Enhanced Language Learning" (TELL), which includes a wide range of digital tools and methods aimed at supporting language acquisition. TELL encompasses approaches like Computer-Assisted Language Learning (CALL), Blended Learning, and Computer-Mediated Communication (CMC), which collectively work to improve language learning outcomes through technology [14]. Studies have shown that TELL can effectively improve various language skills and boost student motivation. However, there are potential drawbacks to an over-reliance on technology, such as its impact on students' focus, attention spans, and social interactions [15, 16]. When applied thoughtfully, TELL can support autonomous, out-of-class learning, providing students with resources tailored to their individual goals and language proficiency levels [17]. Building on this foundation, it is essential to examine how students' expectations align with their actual use of TELL tools, as mismatches in this alignment could influence the effectiveness of language learning.

In Iran, in-class language learning faces significant challenges, including overcrowded classrooms, limited educational resources, and reliance on outdated instructional methods such as the Grammar Translation Method [18]. These factors restrict students' meaningful exposure to English and limit opportunities for active language practice, underscoring the need for robust out-of-class learning options. Addressing these limitations is vital for fostering language proficiency, as in-class instruction alone cannot provide the comprehensive and immersive experiences required for mastering a second language. Without interventions to enhance out-of-class learning, students are at risk of falling behind in their language development, which can limit their academic and professional opportunities in a globalized world.

Technology offers unique advantages for language learners, such as access to native speakers, authentic materials, and interactive, engaging environments [19, 20]. Yet, despite these benefits, Iranian students encounter substantial barriers when attempting to access digital resources outside the classroom. These include limited internet speed, high costs, and restricted access to essential social media platforms, which are often blocked [21]. Such barriers hinder students' ability to fully leverage technology for language learning and to take advantage of the resources available globally. Overcoming these challenges is essential to ensure that students can participate in a technology-driven educational landscape and access opportunities that align with global standards of language education.

Given these constraints, it is crucial to investigate Iranian students' expectations for technology-enhanced learning versus their actual use of such technology beyond the classroom. Analyzing this gap provides insights into students' needs and sheds light on how existing barriers may affect their educational outcomes. By understanding these dynamics, educators and policymakers can develop strategies to address the challenges and improve the accessibility and quality of language learning in Iran, helping students make the most of technology for their language education. Additionally, bridging this gap can contribute to reducing educational inequities and ensuring that all students, regardless of socioeconomic background, have the opportunity to develop the language skills necessary to thrive in a competitive global environment.

Research Objectives

While previous studies have examined students’ expectations or actual use of specific technologies [22, 23], this study provides a broader view by exploring Iranian university students’ expectations and actual use of various technologies for out-of-class English as a Foreign Language (EFL) learning. The study aims to explore two primary objectives: first, to investigate whether a significant disparity exists between students' expectations and their actual utilization of technologies for EFL learning outside the classroom; and second, to examine whether gender-based differences influence both expectations and actual usage patterns of these technologies in the context of EFL learning.

Additionally, a qualitative component explores (1) factors influencing students' use of technology, (2) barriers they encounter, and (3) their suggestions for improving technology-based language learning. These insights can inform strategies to enhance out-of-class learning and address the gap between students’ expectations and their actual experiences.

Review of the Related Literature

Theoretical Background

This study draws on two key theories: Davis’s Technology Acceptance Model (TAM) [24] and Oliver’s EDT [25], both of which provide a foundation for understanding students’ expectations and use of technology.

○ *TAM:* TAM explains how users come to accept and adopt new technology. It highlights two primary factors: Perceived Usefulness (PU), which refers to how much a user believes a technology will improve their performance, and Perceived Ease of Use (PEU), which is the extent to which technology is viewed as user-friendly [24]. These factors shape users' attitudes toward technology, which in turn influence their behavioral intention to use it. In the context of language learning, students are more likely to adopt a technology if they find it useful and easy to use [26].

○ *EDT:* EDT assesses satisfaction by comparing users' expectations with their actual experiences [25]. If a technology’s performance meets or exceeds expectations, positive disconfirmation takes place, resulting in satisfaction. On the other hand, if the performance is below expectations, negative disconfirmation occurs [27]. By applying EDT, this study assumes students will be satisfied if their actual experience with technology aligns with or surpasses their expectations for English learning.

Factors such as cultural background, age, and gender may influence students' technology expectations and usage [28]. Research shows students generally have positive attitudes toward technology in language learning, but barriers like cost, limited knowledge, and internet restrictions can prevent full utilization [1]. This study focuses on Iranian students' expectations and actual use of technology for out-of-class English language learning, aiming to uncover the specific challenges they face and how these impact their language learning beyond the classroom. By integrating TAM and EDT, this study hypothesizes that students' satisfaction with technology is influenced both by its perceived ease and usefulness, as well as by whether their expectations align with their actual experiences.

Qualitative Research Questions

- What factors influence the extent to which Iranian university students utilize technology to support their EFL learning beyond the classroom setting?
- What barriers do Iranian university students face in using technology for EFL learning beyond the classroom?
- What suggestions do Iranian university students have for optimizing the use of technology in EFL learning beyond the classroom?

Research Hypotheses

In accordance with the quantitative research questions, the following null hypotheses were formulated:

- *H01:* No significant difference exists between the expectations of Iranian university students and their actual use of technology for EFL learning beyond the classroom.
- *H02:* There is no significant difference between the expectations of Iranian male and female university students regarding the use of technology for EFL learning beyond the classroom.
- *H03:* There is no significant difference in the actual use of technology for EFL learning beyond the classroom between Iranian male and female university students.

Method

Participants

The research was conducted in the second semester of the Iranian academic year 1402-1403 (2024-2025) at Gonbad Kavous University in Golestan and the University of Bojnord in North Khorasan. Participants were undergraduate English students studying Teaching English as a Foreign Language (TEFL) and English Literature. The qualitative phase included 24 students (11 males, 13 females, ages 21–24), while the quantitative phase involved 48 students (7 males, 41 females, ages 19–30).

The study employed convenience and purposive sampling techniques as outlined by Dörnyei [30]. Universities were selected based on geographical proximity and ease of access, meeting the criteria for convenience sampling. For the qualitative phase, senior English students with more experience in using technology for language learning were chosen through purposive sampling, aimed at identifying participants who were capable of offering varied and comprehensive insights into the research topic. According to Dörnyei, purposive sampling is especially effective in qualitative research for selecting individuals who can offer in-depth perspectives on the phenomenon being studied.
In the quantitative phase, the limited sample size restricted the possibility of random sampling. As a result, all available students were

Research Design

This study utilized a sequential exploratory mixed-methods approach, as described by Creswell [29].

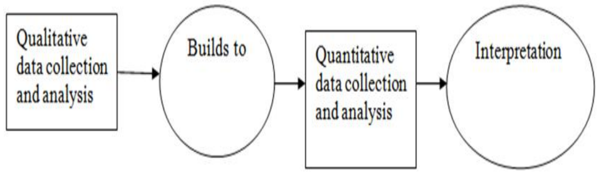

Figure 1: Exploratory Sequential Mixed Methods Design (Creswell, 2012)

The study began with qualitative data collection and analysis to gain a deep understanding of the research problem. This was followed by the development of a questionnaire based on qualitative findings, which was then administered in the quantitative phase to validate and generalize the results.

Instruments

Qualitative Instrumentation

Interview Protocol: Semi-structured, one-on-one interviews were conducted to gather in-depth qualitative data and systematically inform the development of the questionnaire. The interview questions were carefully designed based on a comprehensive review of relevant literature and subsequently reviewed by experienced TEFL professors to ensure their validity and alignment with the study's objectives. To facilitate rich and authentic responses, participants were given the option to answer in either Persian or English, allowing them to express their thoughts with greater ease and precision.

To enhance the credibility of the interview process, the protocol was piloted with 10 English students, enabling the refinement of question phrasing and structure based on their feedback. Additionally, considering participants' preferences and potential constraints, the final interviews were conducted in a written format rather than traditional face-to-face or oral interviews. This approach provided respondents with more flexibility and time to articulate their responses thoughtfully, ultimately improving the depth and accuracy of the qualitative data collected.

Quantitative Instrumentation

Questionnaire: A six-point Likert-scale questionnaire was developed to collect quantitative data based on themes identified during the semi-structured interviews conducted in the initial phase of the study. The questionnaire contained 48 items in total, split into two distinct sections: one assessing students' expectations and the other examining their actual use of technology for language learning. Each section included 24 carefully crafted questions to ensure comprehensive coverage of the research objectives.

Content Validity and Reliability: To ensure the validity of the instrument, experienced EFL professors were invited to review the questionnaire. Their expert feedback helped refine the wording of items for clarity and ensure alignment with the study's goals. Items were assessed for relevance, comprehensiveness, and potential ambiguity. After these revisions, a pilot study was conducted with a sample group to test the instrument.

Reliability analysis using Cronbach's alpha, a statistical measure of internal consistency, produced an impressive score of .92. This result indicated that the questionnaire was highly reliable for measuring the constructs under investigation and suitable for further analysis.

Exploratory Factor Analysis (EFA): EFA was conducted independently for the Actual Use Scale and the Expectations Scale to identify the underlying components within each section of the questionnaire. The following steps were undertaken:

○ *Actual Use Scale:* Principal Component Analysis (PCA) initially identified seven components. However, based on rigorous analytical criteria, including Cattell's scree test and Parallel Analysis, only two components were retained for further examination. Together, these components explained 37.8% of the total variance, with Component 1 contributing 26.4% and Component 2 contributing 11.4%. The Kaiser-Meyer-Olkin (KMO) value of 0.602 indicated moderate adequacy of the sample for factor analysis, while Bartlett's Test of Sphericity provided statistically significant results, confirming the appropriateness of the data for PCA.

○ *Expectations Scale:* PCA revealed four components initially, but once again, two components were retained through the same rigorous procedures. The retained components accounted for a substantial 59.3% of the variance, with Component 1 explaining a dominant 50.0% and Component 2 explaining 9.3%. The KMO value of 0.81 demonstrated excellent sampling adequacy, and Bartlett's Test of Sphericity confirmed the robustness of the dataset for factor analysis.

These analyses validated the structure of the questionnaire and ensured its ability to capture meaningful insights into students' behavior and expectations. Given the study's timing and the need for accessibility, the questionnaire was distributed online via Google Forms. This method allowed participants to complete the survey conveniently, even during their final exams, minimizing disruptions to their academic commitments. The streamlined online administration ensured efficient data collection and broad participation across the target sample.

The comprehensive statistical analyses provided robust validation for the questionnaire while highlighting essential themes through the retained components. By concentrating on these overarching findings, the study emphasized insights that contribute directly to its objectives without overwhelming readers with excessive details about individual questionnaire items. This approach ensured that the analysis remained focused and impactful.

Procedure

Qualitative Data Collection: The qualitative phase of the study commenced in April 2024 with semi-structured interviews designed to explore students' perspectives on technology use in language learning. Purposive sampling was employed to select senior English students, ensuring that participants had sufficient academic experience to provide meaningful insights. To facilitate open-ended discussions, interviews were conducted in person using a paper-and-pencil format, allowing participants to express their thoughts comfortably and seek clarification when necessary. The interviews continued until data saturation was reached, meaning no new themes or insights emerged, which occurred after 24 participants had been interviewed.

To enhance the credibility of the qualitative findings, the interview questions were developed based on a thorough review of relevant literature and expert consultations with TEFL professors. Additionally, the interview protocol was piloted with 10 English students to refine question clarity and ensure that responses effectively captured participants' experiences. The final dataset served as the foundation for developing the questionnaire used in the subsequent quantitative phase.

Quantitative Data Collection: The quantitative phase followed in May 2024 with the development of a Likert-scale questionnaire based on themes and insights derived from the qualitative data. The questionnaire underwent a rigorous review process by experienced EFL professors, who assessed its content validity, clarity, and alignment with the study's objectives. To further ensure reliability, the instrument was piloted with 24 students, and feedback from this process was incorporated into the final version.

The final questionnaire was distributed online via Google Forms in July 2024, ensuring ease of access and participant convenience. This digital administration method was particularly advantageous given the academic calendar, as it minimized disruptions during the exam period and enabled a broader reach beyond those available for in-person participation. A total of 48 students completed the questionnaire, providing quantitative data that was subsequently analyzed to examine patterns in students' expectations versus actual use of technology for language learning.

Results and Findings

Data Analysis

Qualitative Data Analysis: Qualitative data were analyzed manually using Creswell and Creswell's [31] guidelines, which provided a systematic approach to coding and interpreting interview responses.

Quantitative Data Analysis: Statistical analyses included internal consistency checks using Cronbach's alpha and normality tests via skewness and kurtosis. Paired-samples t-tests examined differences between students' expectations and actual use of technology, while independent-samples t-tests assessed gender-based differences in expectations and technology use.

Ethical Considerations

The study adhered to ethical guidelines by obtaining permissions from EFL professors at both universities. Consent forms were provided, and participants were informed of their rights, including confidentiality and the voluntary nature of their participation. Data confidentiality was assured throughout both phases of the study.

Qualitative Results

The qualitative phase involved 24 Iranian university students, aged 21-24, from the University of Bojnord and Gonbad Kavous University. The sample included 11 males and 13 females, with 21 students studying TEFL and 3 studying English Literature, all in their final (8th) semester.

Table 1: Demographic Characteristics of the Subjects in the Qualitative Phase

Characteristic	Category	Frequency
Gender	Male Female	11 13
Age Range	21- 24	24
University	University of Bojnord Gonbad Kavous University	13 11
Field of Study	TEFL English Literature	21 3
Semester	Semester 8	24

In addressing the first research question - What factors influence the extent to which Iranian university students utilize technology to support their EFL learning beyond the classroom setting? - participants identified several key factors:

- *Time and Flexibility:* Many students noted the importance of managing time effectively, with technology enabling them to learn at any convenient time and place.
- *Accessibility:* Easy access to technology, including global educational resources, was highlighted as a major advantage.
- *Cost:* While some technologies are cost-effective, the high cost of internet access was noted as a limitation.

○ *Teacher Support:* Teachers' guidance and motivation were seen as crucial in encouraging effective technology use.

○ *Student Motivation:* Personal interest and desire to use technology were essential for engagement.

○ *Quality and Usability:* Students appreciated technology's ease of use, portability, and engaging features. However, issues like internet quality, filtering, and the need for VPNs were seen as drawbacks.

These insights highlight that factors such as ease of access, time flexibility, cost efficiency, and quality of resources play a significant role in students' technology use for language learning.

Table 2: Factors Affecting Iranian University Students' Use of Technology for EFL Learning Beyond the Classroom

Theme	Code	Representative Quote	Frequency
Time	Using at suitable time	"Time for me is the number one factor since I have to schedule really precisely on when and for how long..." (Student 21)	3
	Preventing time waste	"Technology prevents wasting time on in-person classes, especially when our class isn't held in our city..." (Student 11)	2
	Having enough time	"If I have time, I can spend more time on using technology... social media, find idioms, and take some practices." (Student 6)	6
Place	Usable anytime	"Time and place are in the hands of learners." (Student 20)	4
	Usable anywhere	"We can use it from where we stand." (Student 18)	7
Accessibility	Easily accessible	"The access to technology is easier." (Student 13)	9
	Access to global resources	"We can access materials worldwide, like lectures from popular universities." (Student 11)	3
Cost	Cost-saving	"Cost saving is an important factor." (Student 11)	4
	Free usage	"Being free to use is one of the important factors in choosing a technological tool." (Student 4)	1
	High Internet costs	"We don't have limitations on time and place, but Internet costs are high." (Student 13)	3
Teacher	Guidance in technology use	"Teachers should guide students in using technology and make them aware of it during class time." (Student 23)	3
	Providing motivation	"Teachers and tutors are factors that can provide motivation." (Student 7)	2
Student	Desire to use technology	"Having internal motivation and desire for using technology are really important." (Student 9)	2
Quality	Low Internet quality	"The low quality of the Internet is a drawback, especially for watching videos online." (Student 21)	2
	Filtering and VPN requirements	"The filtering of websites and need for VPNs are other factors." (Student 17)	1
	Ease of use	"Technology is easy to use for today's students." (Student 18)	2
	Visual appeal	"Visual attractions are important in choosing a tool for learning." (Student 4)	2
	Portability	"Being portable is mostly effective in choosing a technology." (Student 5)	2

For the second research question - What barriers do Iranian university students face in using technology for EFL learning beyond the classroom? - participants identified several obstacles:

o *Internet Issues:* Students cited low-speed internet, limited data plans, and high internet costs as major constraints.

o *Restricted Access:* Many educational websites and social media platforms require VPNs due to filtering in Iran, which complicates access.

o *Lack of Guidance:* Absence of teachers or advisors to guide students in selecting appropriate tools or resources was noted as a barrier.

o *Distractions and Health Concerns:* Students mentioned the risk of distraction, potential internet addiction, and eye strain from prolonged screen use.

o *Language Proficiency:* Some students faced difficulties understanding advanced content due to limited language proficiency.

Overall, connectivity issues, restricted access, lack of instructional support, and health concerns are key barriers for Iranian students.

Table 3: Barriers Faced by Iranian University Students in Using Technology for English Language Learning Beyond the Classroom

Theme	Code	Quote	Frequency
Issues related to the Internet	Low-speed Internet connectivity	"The low speed of the Internet can be a major problem." (Student 22)	12
	Limited volume-based Internet connection	"Limited volume-based Internet connection is a major barrier against using technology." (Student 2)	2
	High cost of Internet	"A high cost of buying Internet is a barrier." (Student 1)	4
Issues with Websites, Apps, & Social Media	Being filtered and need for VPNs	"Some educational websites need to use VPNs." (Student 11)	9
	Requiring a subscription	"Some technologies are paid subscription." (Student 17)	6
Challenges in Using & Choosing Technology	Lack of guidance from teachers or advisors	"One of the barriers is the absence of an advisor like a teacher or someone to guide us in using technology." (Student 19)	5
	Confusion due to wide range of materials	"The lack of knowledge in content, meaning that the learner may not know if their preferred content/platform is suitable or not." (Student 20)	2
Disadvantages of Technology	Distraction	"It is most likely that learners get distracted by surfing the net." (Student 14)	3
	Addiction	"It may cause Internet addiction." (Student 14)	1
	Vision problems	"It can hurt humans' eyes." (Student 13)	1
Proficiency Level Challenges	Difficulty understanding advanced content	"Low level of knowledge about a language might cause problems in understanding content of a more advanced level." (Student 21)	1

In response to the third research question - What suggestions do Iranian university students have for optimizing the use of technology in EFL learning beyond the classroom? - students provided the following recommendations:

- *Improved Accessibility:* Participants suggested reducing filtering to make valuable educational content more accessible.
- *Scheduling and Consistency:* Setting a regular study schedule was advised to make learning more structured.
- *Diversified Learning Tools:* Developing age-appropriate and engaging apps and platforms would cater to diverse learner needs.
- *Gamification:* Incorporating game elements was proposed as a way to make learning more engaging.
- *Effective Tool Selection:* Students recommended choosing a few high-quality resources rather than using many different tools.
- *Teacher Support:* Teachers should inform students about effective ways to use technology for language learning.
- *Focused Use:* Students suggested limiting distractions by locking other apps and focusing only on learning.
- *Personalization and Assessment:* Using technology to personalize learning and assess progress was seen as beneficial.

These suggestions emphasize the need for more accessible resources, consistent study habits, and personalized tools to optimize language learning through technology.

Table 4: Suggestions by Iranian University Students for Effective Use of Technology in English Language Learning Beyond the Classroom

Theme	Code	Quote	Frequency
Accessibility	Access without filtering	"Providing and not filtering good contents and sharing them more can be suggested." (Student 20)	2
Scheduling	Regular study schedule	"We should set a regular schedule for studying." (Student 10)	4
	Utilizing free time	"During free time, listening to podcasts, watching YouTube videos, and listening to music can help you learn a new language." (Student 22)	1
Diversification	Develop diverse applications for all ages	"More diverse and interesting applications should be developed for children, as well as language learners of all ages." (Student 12)	2
Gamification	Integrate games into learning technology	"Gamification is the best way, in my opinion, for teaching English." (Student 18)	1
Effective Use Tips	Select high-quality technology	"Try to find the best tools based on your needs. There's no benefit in using too many websites; use a few good ones." (Student 15)	7
	Teachers guide technology use	"Teachers should inform students about using technology for English learning, as most learners aren't aware of the resources available." (Student 23)	2
	Focus on learning, avoid social distractions	"We should use mobile phones, apps, and websites for learning, not for wasting time on unrelated social media." (Student 13)	2
	Lock other apps while studying	"We should set a specific learning time each day, locking other apps on mobile phones and computers during that time." (Student 8)	1

Theme	Code	Quote	Frequency
	Learn how technology works	"Understand how technology works and in what ways it can be used effectively before starting." (Student 17)	2
	Take notes during technology-assisted learning	"We should write down new concepts to review intensively." (Student 10)	2
	Share knowledge with peers	"Sharing information with other learners and discussing it is another suggestion." (Student 14)	1
	Keep technology updated	"We should update phones, laptops, etc., regularly." (Student 6)	1
	Use technology for self-assessment	"Educational applications and sites with assessment options can help us gauge our learning progress." (Student 7)	2
	Tailor learning to personal needs	"Technology allows us to personalize learning based on our interests, learning styles, and skills for optimal use." (Student 9)	3

Quantitative Results

The quantitative phase included 48 students from the same universities, with 41 females and 7 males, aged 19-30. Participants were predominantly TEFL majors across various semesters. Skewness and kurtosis values fell within the acceptable range (±2.0), indicating that the data were normally distributed, permitting the use of parametric tests such as paired-samples and independent-samples t-tests.

Table 5: Demographic Characteristics of the Subjects in the Quantitative Phase

Characteristic	Category	Frequency
Gender	Male	7
	Female	41
Age Range	19- 30	
University	University of Bojnord	26
	Gonbad Kavous University	22
Field of Study	TEFL	34
	English Literature	14
Semester	Semester 2	5
	Semester 4	22
	Semester 6	7
	Semester 8	14

Table 6: Skewness and Kurtosis values of Normality

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Actual use	48	.320	.343	-.453	.674
Expectations	48	-.604	.343	-.392	.674

Comparison of Students' Expectations vs. Actual Use of Technology

Table 7: Paired Samples Test for Iranian University Students' Expectations and Actual Use of Technology

		Mean	N	Std. Deviation	1(df)	Sig.
Pair 1	Actual use	119.79	48	11.745	-.858(47)	.395
	Expectations	121.54	48	17.518		

A paired-samples t-test was performed to assess the difference between Iranian university students' expectations and their actual use of technology for English language learning beyond the classroom. The results showed no significant difference between students' actual use (M = 119.79, SD = 11.745) and their expectations (M = 121.54, SD = 17.518), t (47) = -.858, p = .395> 0.05. The mean difference between the two variables was -1.75, with a 95% confidence interval of -5.85 to 2.35. Although the eta squared statistic was 0.93, indicating a large effect size, the lack of statistical significance led to the acceptance of the null hypothesis, suggesting that students' actual use of technology aligns closely with their expectations.

Gender-Based Comparison of Expectations

An independent-samples t-test showed no significant difference between females (M = 120.24, SD = 17.632) and males (M =129.14, SD =15.889; t (46) = -1.250, p = .218. The mean difference of -8.90 had a 95% confidence interval ranging from -23.24 to 5.44. The effect size was small, as indicated by an eta squared value of 0.032. This result suggests that gender does not significantly impact students' expectations of technology use in English language learning beyond the classroom.

Gender-Based Comparison of Actual Use

An independent-samples t-test indicated no significant difference in actual technology use scores between female students (M = 118.98, SD = 10.45) and male students (M = 124.57, SD = 17.92), t(6.713) = -0.803, p = .449. The mean difference was -5.60, with a 95% confidence interval ranging from -22.22 to 11.03. The effect size was small (η^2 = 0.013), supporting the null hypothesis that gender does not significantly impact the actual use of technology for English language learning beyond the classroom.

Discussion

This study explored the gap between Iranian university students' expectations and their actual use of technology for out-of-class EFL learning, aiming to enhance the quality of this educational context. A sequential exploratory mixed-methods design was used to gain a comprehensive understanding.

The qualitative phase revealed several barriers faced by Iranian students, such as low internet speed, filtering of websites, and high costs. These infrastructural and political constraints often pose significant challenges to seamless technology use in the Iranian context. Despite these hurdles, students displayed notable resilience by finding creative and resourceful ways to circumvent these barriers. For instance, the use of virtual private networks (VPNs) and offline resources enabled students to continue their language learning endeavors effectively, even when faced with restricted access to online platforms and tools.

Table 8: Independent Samples Test for Iranian Male and Female Students' Expectations of Technology

	Gender	N	Mean	Std. Deviation	t(df)	Sig.
Expectations	Female	41	120.24	17.632	-1.250 (46)	.218
	Male	7	129.14	15.889		

Table 9: Independent Samples Test for Iranian Male and Female Students' Actual Use of Technology

	Gender	N	Mean	Std. Deviation	t(df)	Sig.
Actual use	Female	41	118.98	10.451	-0.803 (6.713)	.449
	Male	7	124.57	17.924		

Quantitative analysis showed no significant difference between students' expectations and their actual use of technology, indicating that, despite these barriers, students were generally satisfied with their access to technology for language learning. This suggests that while external constraints remain a challenge, students managed to align their expectations with their actual experiences through adaptive strategies and resourceful decision-making. This satisfaction could be attributed to their autonomy in choosing when, how, and which digital tools to use, which may mitigate frustrations stemming from infrastructural limitations.

This finding aligns with the TAM and EDT, suggesting that students' actual technology use met their expectations, leading to satisfaction. The alignment between expectations and experiences highlights the adaptability and resourcefulness of students in optimizing their technology use, even under restrictive circumstances. Additionally, students reported effective use of technology for language learning, demonstrating resilience in overcoming challenges such as the distraction potential of digital tools and the lack of adequate teacher guidance. Notably, they emphasized the importance of flexibility in technology use, which aligns with the tenets of TAM, where ease of use and perceived usefulness strongly influence technology adoption and satisfaction.

This result contrasts with previous studies by Algubaisi [14] and Dashtestani [1], which suggested that barriers like filtering and lack of teacher support hinder effective technology use. However, those studies focused on in-class contexts where students had limited control, whereas this study examined out-of-class learning, where students exercise greater autonomy. The autonomy afforded in out-of-class settings enables students to make individual choices regarding their learning tools, platforms, and schedules, tailoring their experiences to their preferences and learning styles. This autonomy may explain why students in this study reported greater satisfaction despite external challenges, as they were able to exercise control over their learning experiences.

This study also reinforces the importance of supporting students' autonomy and agency in language learning. The findings indicate that while infrastructural and political constraints persist, students' adaptability and self-directed learning approaches allow them to leverage available technological resources effectively. Educators and policymakers should recognize the resilience of students in navigating these challenges and support their efforts by addressing systemic barriers, such as internet filtering and limited teacher support, to optimize their technology-driven learning experiences.

The study's findings of no significant gender differences in expectations or actual use of technology are noteworthy in several ways. These findings align with studies by Desta et al. [32] and Lee et al. [33], which also reported uniform patterns of technology use across genders. This trend may reflect a shift in societal dynamics, particularly with the increasing integration of technology into daily life, which has likely reduced traditional gender-based gaps in digital literacy and skills. The widespread availability of user-friendly digital tools and the normalization of technology in education and entertainment have fostered an environment where both male and female students are equally adept at navigating technological resources.

The contrast with studies by Li and Kirkup [34] and Volman et al. [35], which observed gender-based differences in technology use, could be attributed to contextual factors. Those studies may have been conducted in settings or time periods where cultural norms, educational access, and exposure to technology varied significantly between genders. In the current study, the similar challenges faced by male and female students, such as internet restrictions, high costs, and infrastructural limitations, appear to have overshadowed any potential disparities in access or use. These shared obstacles may have created a level playing field, compelling both genders to develop comparable levels of competence and adaptability in using technology for language learning.

Furthermore, the evolving nature of education, where digital tools are now integral to academic practices, may have contributed to diminishing gender-based differences. Initiatives aimed at promoting equitable access to technology in education, combined with the growing emphasis on digital skills development, have likely played a pivotal role in ensuring that both genders are equally equipped to utilize technology effectively.

Students' expressed need for teacher guidance underscores the critical role educators play in bridging the gap between technology availability and its effective utilization for learning. While students demonstrated autonomy and motivation in their use of technology, their call for structured guidance highlights the limitations of self-directed approaches, particularly in identifying and leveraging high-quality resources. This resonates with findings by Esfandiari and Gawhary [36] and Healey [37], which emphasize that teacher involvement is instrumental in fostering autonomy. Teachers can serve as facilitators, helping students optimize their use of technology through tailored recommendations, troubleshooting technical challenges, and promoting time management strategies.

Moreover, teacher guidance could be especially valuable in addressing the issue of distractions associated with technology use, a challenge frequently reported by students. By providing clear objectives, curated resources, and practical tips for maintaining focus, educators can help students harness the potential of technology while mitigating its drawbacks. The development of structured learning routines, as suggested by students in this study, further supports the notion that teacher involvement is crucial in creating a balanced and effective technology-enhanced learning environment.

In addition to technical and strategic support, teachers can foster a deeper understanding of how to align technology use with specific language acquisition goals. For instance, guiding students to integrate gamified learning tools, collaborative platforms, or interactive media into their study routines could enhance engagement and motivation while yielding better outcomes. Ultimately, such guidance not only enhances immediate learning experiences but also equips students with the skills needed for lifelong learning in an increasingly digital world.

Conclusions

This study reveals that Iranian university students have largely adapted to using technology for EFL learning beyond the classroom, finding satisfaction despite structural and political barriers. However, students expressed a need for more teacher guidance to maximize the effectiveness of their technology use. The study highlights the essential role that technology plays in out-of-class English language learning in Iran, with students demonstrating resilience against challenges like internet filtering and high costs. Despite these obstacles, students' expectations generally aligned with their actual usage, leading to overall satisfaction.

Using a mixed-methods approach, the research investigated Iranian students' expectations versus their actual use of technology for out-of-class English language learning. Qualitative findings identified key factors influencing technology use, including time flexibility, accessibility, cost, and teacher support, while barriers included poor internet quality, filtering, and a lack of guidance. Quantitative results showed no significant differences between students' expectations and actual use, and no significant gender-based differences in either expectations or usage patterns.

The study underscores the importance of technology in supporting language learning beyond the classroom, even in restrictive environments. It suggests that policymakers and educators should support this trend by reducing unnecessary restrictions and providing guidance to help students fully benefit from digital learning tools. Students also suggested enhancing accessibility, establishing regular study routines, and personalizing learning to further improve the effectiveness of technology in their language-learning journey.

Pedagogical Implications and Suggestions for Future Research

The study highlights the need for a more supportive approach to integrating technology into language learning in Iran. Rather than imposing additional restrictions, Iranian authorities should consider reducing barriers, such as internet filtering, since students have demonstrated they can use technology responsibly and effectively for educational purposes. The findings show that students are satisfied with their technology use in learning, suggesting that investments in restrictive measures may be unnecessary. Additionally, training teachers to guide students in effective technology use would further enhance the benefits of digital learning tools.

Pedagogical Implications

- *Teacher Training:* Teachers should receive training to effectively guide students in using technology for language learning, equipping them with strategies to maximize the educational potential of these tools.
- *Policy Recommendations:* Iranian authorities should reconsider restrictive policies, such as internet filtering, recognizing that students require access to digital resources for learning and have shown responsible use of these technologies.
- *Support for Autonomy:* Teachers should promote autonomous learning by motivating students to engage with technology effectively beyond the classroom, fostering independent, self-directed learning.

Suggestions for Future Research: To build on these findings, future studies could address several areas for a broader understanding of technology's role in language learning:

- *Diverse Educational Levels:* Research should explore students' expectations and technology usage across various educational levels, including elementary and high school, to assess developmental differences in technology needs.
- *Broader Demographics:* Expanding research to include students from different academic disciplines could offer insights into

the general applicability of these findings across fields.

○ *Teacher Perspectives:* Including teachers in future studies would provide valuable insights into their perspectives on supporting out-of-class technology use for language learning.

○ *Contextual Comparisons:* Comparative studies across different cultural or geographical settings would help determine the generalizability of these findings and identify unique challenges or advantages in diverse environments.

The study faced several limitations. A small sample size, limited to English-major students from two universities in Iran, may affect the generalizability of the results. Furthermore, the sample included only a few male students, and data collection coincided with final exams, which may have limited participation. Lastly, the research was geographically restricted to Gonbad Kavous University and the University of Bojnord, which may not represent the broader Iranian student population. Future research could expand to different fields of study and geographical locations to provide a broader perspective.

Authors' Contribution

Author 1: Conceptualization, Writing original draft, Data curation, Investigation, and Formal analysis. Author 2: Methodology, Project administration, and Supervision. Author 3: Validation, review, and editing

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Appendix A
Interview Protocol for University Students

I. Demographic & Personal Information
1. Name:
2. Age:
3. Gender:
4. University Name:
   - ☐ University of Bojnord
   - ☐ Gonbad Kavous University
5. Field of Study:

II. Subjects' Actual Use of Technology & Technology Use Expectations

6. Do you use technology to assist with learning English?
7. What technologies do you use outside the classroom to learn English? *(Examples: language learning tools, applications, websites, social media platforms such as Instagram, WhatsApp, YouTube, Facebook, etc.)*
8. How does technology help you with English learning outside the classroom?
9. Which technologies or social media platforms do you recommend for learning English outside the classroom?
10. What are the advantages of using such technologies for English learning outside the classroom?
11. What challenges or barriers do you face in using technology for English learning outside the classroom?
12. What factors influence how frequently or effectively you use technology for English learning outside the classroom? *(Consider aspects such as time, location, teacher support, institutional policies, cost, accessibility, and technology quality.)*
13. What suggestions do you have for maximizing the benefits of technology in English language learning outside the classroom?
14. What are your expectations regarding technology-enhanced English language learning outside the classroom?
15. How do you envision the future of technology in English language learning in a global context?
16. How do you foresee the future of technology in English language learning within the Iranian context?
17. Do you have any additional comments or insights to share?

Appendix B
Survey Questionnaire

Iranian University Students' Expectations and Actual Use of Technology in English Language Learning Beyond the Classroom

Introduction

The researcher is an MA student conducting a study on Iranian university students' expectations and actual use of technology in English language learning beyond the classroom. The primary objective of this questionnaire is to determine whether there is a significant difference between students' expectations and their actual use of technology for English learning outside the classroom. Your honest and clear responses will be invaluable in contributing to this research. All responses will remain confidential and will be used solely for academic purposes.

Consent Form

By participating in this study, I acknowledge that:

✅ My participation is voluntary.

✅ I allow the researcher to use my responses as research data.

✅ My identity will remain anonymous, and all information provided will be treated with confidentiality.

☐ I agree to participate in this study.

Section I: Biographical Data
1. Full Name (Optional):
2. Age:
3. Gender:

☐ Female

☐ Male

4. University Name:

☐ University of Bojnord

☐ Gonbad Kavous University

5. Field of Study:

☐ TEFL

☐ English Literature

6. Semester:

☐ 2

☐ 4

☐ 6

☐ 8

Section II: Actual Use of Technology in English Language Learning

Instructions: Please indicate your level of agreement with the following statements using the scale below:

1 = Strongly Disagree
2 = Disagree
3 = Slightly Disagree
4 = Slightly Agree
5 = Agree
6 = Strongly Agree

I use technology to learn English outside the classroom because...

#	Statement	1	2	3	4	5	6
1	It is more fun and interesting.	☐	☐	☐	☐	☐	☐
2	It improves my motivation.	☐	☐	☐	☐	☐	☐
3	It is more engaging.	☐	☐	☐	☐	☐	☐
4	It is easy to use.	☐	☐	☐	☐	☐	☐
5	It is free to use.	☐	☐	☐	☐	☐	☐
6	It provides easy access to academic sources.	☐	☐	☐	☐	☐	☐
7	I can access it anytime and anywhere.	☐	☐	☐	☐	☐	☐
8	It is easily accessible.	☐	☐	☐	☐	☐	☐
9	It provides authentic materials.	☐	☐	☐	☐	☐	☐
10	It offers a wide range of learning materials.	☐	☐	☐	☐	☐	☐
11	It provides visually enhanced materials.	☐	☐	☐	☐	☐	☐
12	It makes learning English easier.	☐	☐	☐	☐	☐	☐
13	It speeds up the learning process.	☐	☐	☐	☐	☐	☐
14	It is regularly updated with new content.	☐	☐	☐	☐	☐	☐
15	I can communicate with native speakers.	☐	☐	☐	☐	☐	☐
16	I can search for any topic I want to learn.	☐	☐	☐	☐	☐	☐
17	It provides self-study opportunities.	☐	☐	☐	☐	☐	☐
18	It saves my time and energy.	☐	☐	☐	☐	☐	☐
19	It improves my English speaking skills.	☐	☐	☐	☐	☐	☐
20	It improves my English writing skills.	☐	☐	☐	☐	☐	☐
21	It improves my English reading skills.	☐	☐	☐	☐	☐	☐
22	It improves my English listening skills.	☐	☐	☐	☐	☐	☐
23	It improves my English grammar skills.	☐	☐	☐	☐	☐	☐
24	It improves my English pronunciation skills.	☐	☐	☐	☐	☐	☐

Section III: Expectations of Technology in English Language Learning

Instructions: Please indicate your level of agreement with the following statements using the same scale (1–6).

I expect technology for English language learning outside the classroom to...

#	Statement	1	2	3	4	5	6
1	Be easily accessible anywhere.	☐	☐	☐	☐	☐	☐
2	Be of high quality.	☐	☐	☐	☐	☐	☐
3	Be easy to understand.	☐	☐	☐	☐	☐	☐
4	Be user-friendly.	☐	☐	☐	☐	☐	☐
5	Cater to different proficiency levels.	☐	☐	☐	☐	☐	☐
6	Make learning more engaging.	☐	☐	☐	☐	☐	☐
7	Simplify the learning process.	☐	☐	☐	☐	☐	☐
8	Save time and effort.	☐	☐	☐	☐	☐	☐
9	Provide feedback on my performance.	☐	☐	☐	☐	☐	☐
10	Offer a structured daily learning routine.	☐	☐	☐	☐	☐	☐
11	Provide a study timetable.	☐	☐	☐	☐	☐	☐
12	Include useful and diverse materials.	☐	☐	☐	☐	☐	☐
13	Offer fast internet access.	☐	☐	☐	☐	☐	☐
14	Provide authentic English materials.	☐	☐	☐	☐	☐	☐
15	Function offline when necessary.	☐	☐	☐	☐	☐	☐
16	Be free or affordable.	☐	☐	☐	☐	☐	☐
17	Be unrestricted and unfiltered.	☐	☐	☐	☐	☐	☐
18	Improve all aspects of English language skills.	☐	☐	☐	☐	☐	☐

Please leave your phone number or Telegram ID if you are open to further communication regarding this study. Thank you for your time and valuable contribution to academic research! Your input is sincerely appreciated.

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ORIGINAL RESEARCH PAPER

A Mixed-Methods Probe into CALL and non-CALL Integrated Assessment and EFL Learners' Summary Writing Ability

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ABSTRACT

Background and Objectives: Educational research has paid close attention to technology in language learning, especially computer-assisted language learning. CALL provides a dynamic and interactive platform for students to engage with language learning activities, multimedia resources, and communication channels. CALL has immense potential in helping English as a Foreign Language (EFL) learners to develop their skills through the summary writing process. Computer-Assisted Language Learning (CALL) has emerged as a prominent approach in language education, utilizing computer technology and interactive materials to support language learning. This mixed-methods study aimed to explore the effectiveness of CALL in enhancing the summary writing ability of English as a Foreign Language (EFL) learners, compared to a non-CALL integrated assessment.

Materials and Methods: The study employed a mixed-methods approach, combining quantitative data analysis and qualitative insights. Two intact classes of intermediate-level EFL learners, comprising 40 participants, were selected based on their intermediate language proficiency. Various measures, including placement tests, reading materials, scoring guidelines, interviews, and self-assessment reports, were utilized. Data analysis involved a One-Way Analysis of Covariance (ANCOVA) to examine the impact of instructional methods on summary writing performance.

Findings: The findings emphasized the potential of CALL-integrated assessments, highlighting personalized instruction, timely feedback, authentic writing practice, collaborative learning, integrated language skills development, and effective curriculum design.

Conclusions: The study's implications extend to personalized instruction, authentic practice, collaborative learning, integrated language skills, curriculum design, and formative assessment. The results contribute to the ongoing discourse on technology in language learning and demonstrate the positive impact of CALL on EFL learners' summary writing ability. Integrated assessment approach for non-calls involves self-reflection. Students are encouraged to analyze their own writing by examining their own progress, strengths, and weaknesses. Students can take ownership of their language learning and learn it in their own way. It enables students to set targets and track their progress over time. Reflection on writing skills can enhance students' self-awareness and a proactive approach to learning a language.

NUMBER OF REFERENCES
38

NUMBER OF FIGURES
2

NUMBER OF TABLES
15

مقاله پژوهشی

بررسی ترکیبی ارزیابی یکپارچه با استفاده از فناوری در مقابل ارزیابی بدون استفاده از فناوری و توانایی نوشتن خلاصه توسط زبان آموزان ایرانی

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چکیده

پیشینه و اهداف: تحقیقات آموزشی توجه زیادی به فناوری در یادگیری زبان، به ویژه یادگیری زبان به کمک رایانه، داشته است. یادگیری زبان به کمک رایانه بستری پویا و تعاملی برای دانش‌آموزان فراهم می‌کند تا با فعالیت‌های یادگیری زبان، منابع چندرسانه‌ای و کانال‌های ارتباطی درگیر شوند. این نوع یادگیری پتانسیل عظیمی در کمک به زبان‌آموزان انگلیسی به عنوان زبان خارجی برای توسعه مهارت‌هایشان از طریق فرآیند خلاصه‌نویسی دارد. یادگیری زبان به کمک رایانه به عنوان یک رویکرد برجسته در آموزش زبان ظهور کرده است که از فناوری رایانه و مواد تعاملی برای پشتیبانی از یادگیری زبان استفاده می‌کند. این مطالعه ترکیبی با هدف بررسی اثربخشی یادگیری زبان به کمک رایانه در افزایش توانایی خلاصه‌نویسی زبان‌آموزان انگلیسی به عنوان زبان خارجی در مقایسه با ارزیابی یکپارچه بدون کمک رایانه انجام پذیرفت. مطالعه به هدف دریافت نتایج شایسته‌ای درباره کارایی فعالیت‌های نوشتاری مبتنی بر رایانه و ارزیابی یکپارچه غیر- رایانه در بهبود توانایی نوشتن خلاصه در زبان انگلیسی برای زبان‌آموزان می‌پردازد.

روش‌ها: این مطالعه از رویکرد روش‌های ترکیبی، شامل ترکیب تحلیل داده‌های کمی و بینش‌های کیفی، استفاده کرد. دو کلاس از زبان‌آموزان سطح متوسط، شامل ۴۰ شرکت‌کننده، بر اساس مهارت زبانی متوسطشان انتخاب شدند. معیارهای مختلفی از جمله آزمون‌های تعیین سطح، مطالب خواندن و درک مفاهیم، دستورالعمل‌های نمره‌دهی، مصاحبه‌ها و گزارش‌های خودارزیابی مورد استفاده قرار گرفت. تجزیه و تحلیل داده‌ها شامل تحلیل کوواریانس یک‌طرفه برای بررسی تأثیر روش‌های آموزشی بر عملکرد خلاصه‌نویسی بود.

یافته‌ها: یافته‌ها نشان داد که ارزیابی‌های یکپارچه با استفاده از فناوری قابلیت برگزاری آموزش شخصی‌سازی شده، بازخورد به‌موقع، تمرین نوشتاری متعارف، یادگیری همکارانه، توسعه مهارت‌های زبانی یکپارچه و طراحی برنامه درسی را دارا بودند.

نتیجه‌گیری: پیامدهای این مطالعه به آموزش شخصی‌سازی‌شده، تمرین اصیل، یادگیری مشارکتی، مهارت‌های زبانی یکپارچه، طراحی برنامه درسی و ارزیابی تکوینی گسترش می‌یابد. نتایج به گفتمان جاری در مورد فناوری در یادگیری زبان کمک می‌کند و تأثیر مثبت یادگیری زبان با کمک رایانه را بر توانایی خلاصه‌نویسی زبان‌آموزان نشان می‌دهد. رویکرد ارزیابی یکپارچه برای غیرحضوری‌ها شامل خوداندیشی است. دانش‌آموزان تشویق می‌شوند تا با بررسی پیشرفت، نقاط قوت و ضعف خود، نوشته‌های خود را تجزیه و تحلیل کنند. دانش‌آموزان می‌توانند از استقلال بیشتری دریادگیری زبان برخوردار شوند و آن را به روش خود بیاموزند. این امر زبان‌آموزان را قادر می‌سازد تا اهدافی را تعیین کرده و پیشرفت خود را در طول زمان پیگیری کنند. تأمل در مهارت‌های نوشتاری می‌تواند خودآگاهی زبان آموزان و رویکرد پیشگیرانه آنها را در یادگیری زبان افزایش دهد.

Introduction

Educational research has paid close attention to technology in language learning, especially Computer-Assisted Language Learning (CALL). CALL provides a dynamic and interactive platform for students to engage with language learning activities, multimedia resources, and communication channels. CALL has immense potential in helping English as a Foreign Language (EFL) learners to develop their skills through the summary writing process [1]. When CALL is utilized, students can access a wide range of resources such as online text materials, audiovisuals, and interactive exercises that could facilitate ease in learning summarizing techniques and thus improve their overall writing ability [2]. This integration of technology not only promotes better learning but also provides personalized and self-directed learning since students can engage in summary writing skills within a supportive and adaptive environment. Also, CALL can offer chances for immediate feedback, in which learners can locate their weak points in writing and thus address them. The integration of CALL into EFL writing instruction presents a potentially promising way of increasing students' engagement, motivation, and autonomy as learners, leading to more efficient and enjoyable summary writing.

In this respect, integral to the effective implementation of CALL in EFL writing instruction is the notion of integrated assessment. To this end, Lee has postulated that integrated assessment is meant to bridge the gap between teaching, learning, and assessment since these three aspects interrelate with each other in order to bring a maximum advantage to learners [3]. Integrated assessment may bring in a sea change to the traditional way of teaching and assessment of EFL writing skills if used in harmony with technologically assisted learning environments like CALL [4]. Due to integrated assessment, one can align learning objectives with instructional activities and assessment tasks, assuring coherence and comprehensiveness when evaluating students' summary writing abilities. Through integrated assessment, the teachers are able to devise writing tasks that are closer to real-life situations and involve meaningful language use, thus engaging students in using their summarization skills in contexts more similar to real life. In CALL-based integrated assessment, learners instantly receive feedback and suggestions for improving their work through automatic or semi-automated means. Holistic assessment enhances the reliability and validity of evaluation practices while creating a learner-centered formative learning atmosphere.

Although CALL and integrated assessment individually have been the subject of significant research, their combined effect on EFL learners' summary writing ability is still a new strand of research. Ghanbari and Abdolrezapour propose incorporating emotional intelligence in an integrated writing assessment to enhance the construct validity of assessment practices [5]. Besides, integrated assessment can offer a more complete picture regarding the summary writing skill of students, as well as their involvement in writing, by considering learners' emotions and affective factors. The effectiveness of integrated assessment, as for, and of learning was also reflected in Sadeghi and Rahmati, within a large-scale exam preparation course [6]. There is a comprehensive assessment of the development of learners, their metacognitive capabilities, and their own thoughts and feelings. As for self-assessments, peer reviews, and teacher feedback, learners can know where they are strong, where they are weak, and engage in reflective practices aimed at continuously improving themselves. These studies therefore point to the potential benefits of integrating CALL and integrated assessment and stress the need for expanding research into this area to comprehensively understand how these variables interact and influence EFL learners' summary writing performance.

Further investigation is needed to fully realize the benefits of the integrated approach of CALL, integrated assessment, and summary writing skills. Some of the leading works have been done in this regard by Plakans et al., Uludag et al., and Deane et al. [7, 8, 9]. Plakans et al. explored the effects of CALL and integrated assessment on EFL learners' performance in summary writing, emphasizing providing learners with ample opportunities to practice summary writing using technology [10]. Uludag et al. examined the effect of integrated assessment on learners' self-regulation strategies while performing the summary writing task and discussed how it could help develop learners' metacognitive awareness by fostering self-directed learning [9].

According to Deane et al., automatic writing assessment tools in the context of computer-assisted language learning had their own share of pros and cons, similar to the evaluation of summaries[7]. These, among other studies in the field, pave the way for further research to investigate the complex relationship between CALL, integrated assessment, and summary writing skills. Using the interaction between the variables and their impact, researchers can make evidence-based recommendations for designing instructional and assessment strategies that support learners' ability to develop their summary writing skills in technologically advanced learning environments. Writing proficiency plays a crucial role in language acquisition, enabling learners to effectively communicate their thoughts and ideas [11].
To achieve this goal, it is necessary to employ new approaches and teaching methods that will allow learners to develop writing skills.

This assertion is particularly true since technology like CALL has the capacity to generate engaging interactive learning environments for enhancing students' writing proficiency and imbuing them with confidence and precision when using the written word to express themselves [12]. Through CALL, writing experiences are bound to become more genuine. It enables the practicing opportunity in which the learners become active agents in improving their own writing skills [13, 14]. Enabling approaches focused on writing processes-oriented will ease the process of developing writing skills among the learners by focusing on the various stages of writing. Therefore, enabling students to achieve better qualities of written output [15, 16].

The existing gap in information on the association between CALL, IA, and summary writing hinders the development of good teaching and assessment strategies for enhancing writing skills among students. In this respect, it is important to seek innovative approaches that can be embedded in a variety of activities in language learning classes. Such diverse activities as group discussions, project-based assignments, etc., need to be incorporated into the class work for teachers to provide a stimulating learning environment that addresses the needs of each student. This type of approach supports student participation and caters to different student learning styles; it encourages long-term retention of the language content learned. Such an approach requires research on whether it will work, and if it does, how it would affect language teaching and policymakers. The study aimed to provide valuable insights into the effectiveness of CALL-based writing activities and non-CALL integrated assessment in improving EFL learners' summary writing ability. More specifically, this mixed-methods study aimed to explore the effectiveness of CALL in enhancing the summary writing ability of English as a Foreign Language (EFL) learners, compared to a non-CALL integrated assessment. The researchers formulated the following questions:

- Is there a significant difference between the CALL integrated assessment group and the non-CALL integrated assessment group?

- Is there a significant difference between the CALL non-integrated assessment group and the non-CALL non-integrated assessment group?

- Is there a significant difference between the CALL non-integrated assessment group and the non-CALL integrated assessment group?

- Is there a significant difference between the

CALL integrated assessment group and the non-CALL non-integrated assessment group?

- Is there a significant difference between the CALL integrated assessment group and the CALL non-integrated assessment group?

- Is there a significant difference between the non-CALL integrated assessment group and the non-CALL non-integrated assessment group?

- What is the students' attitude toward using integrated assessment in teaching summary writing?

Review of the Related Literature

Computer-Assisted Language Learning (CALL)

Computer-Assisted Language Learning (CALL) has emerged as a promising approach to enhance language education [12]. Despite its potential benefits, there are underexplored areas within CALL, particularly in the integration of technology into the writing process and the use of integrated assessment [17, 18, 19]. The integration of technology into the writing process is an essential aspect that requires further investigation [20]. Research is needed to explore how technology can effectively support different stages of writing, such as pre-writing, drafting, revising, and editing. This exploration can involve the use of writing software, online collaborative platforms, and multimedia resources to enhance writing proficiency [17, 19]. Furthermore, the use of integrated assessment within CALL is an area that needs attention [13]. Integrated assessment involves incorporating assessment tasks and feedback within the CALL environment to provide immediate and personalized feedback on writing [17]. However, there is a lack of comprehensive studies on the effectiveness of integrated assessment in CALL for evaluating writing skills. Research into AWE, peer feedback tools, and teacher-mediated feedback since CALL will provide information that points out how integrated assessment could better improve the performance of the learners in the acquisition of writing skills [21]. Comprehensive studies that cover the knowledge deficiencies of how technology integration can benefit or harm the writing process as well as how integrated assessment with the CALL could be put into operation within the contemporary second/foreign language learning context [22, 17] Computer-Assisted Language Learning (CALL) has a rich history dating back to the 1960s when it was first introduced in higher education institutions [23]. However, widespread implementation of CALL began in the 1970s, particularly in European schools [23]. Rather than being a standalone methodology, CALL is considered a supplementary tool that enhances language learning [24].

CALL encompasses a wide range of definitions and is often described as a process in which learners use computers to improve their language skills [25]. It is a dynamic discipline that combines pedagogy and technological advancements, inspiring educators to employ innovative techniques for teaching language skills [25]. Research in the last few decades has shown the positive role of digital technology in ESL/EFL learning [26, 27, 28]. According to Rainie and Horrigan, the Internet nowadays is part of the regular structure of everyday life in America [29]. Crystal also says that the languages used in computer-mediated communication might develop into the standard ways of communities [30]. In Iran, however, despite the large number of internet users engaged in educational purposes, the adoption of technology in language teaching has been slow [31].

The integration of CALL into the language classroom offers great benefits for both teachers and students. CALL enhances motivation, relevancy, authenticity, and engagement in language learning [32, 33]. Integrating digital technology into language instruction, CALL presents interactive and dynamic learning experiences that engage the students' interest and make language learning more enjoyable and meaningful. It offers access to authentic materials and real-world contexts, allowing students to practice their language skills in practical situations. Moreover, CALL has become an integral part of language programs, promoting learner autonomy and independent learning [19, 10]. Through CALL, students will access some online resources, language-learning apps, and some interactive material adapted to individual learners' needs, thus letting them manage their own process and pace of improvement.

Relevant Empirical Studies

Larsen-Freeman has contributed much to the theoretical grounds of CALL [34]. She indicates the advantages of integrating technology into language teaching, which include increasing motivation, promoting learner autonomy, and access to authentic language resources. Another important figure in CALL is Chapelle, who discusses how technology can enhance language assessment [17]. Her work shows how technology can make assessments more authentic and more interactive, thus providing a more complex and engaging experience for learners. Motteram investigated the use of online platforms and virtual environments as support for language learning [35]. Online language courses, virtual language exchanges, and social networking sites might all be used to foster an authentic learning environment. Levy discussed language learning with computer-mediated communication Levy [18]. He explored how a set of synchronous and asynchronous online communication tools might aid language acquisition and intercultural communication skills.

Hailah Alhujaylan, in one of the studies, assesses the effectiveness of CALL on the students' improvement of writing skills in the academic setting with 60 Saudi female undergraduate students. In this regard, she has divided her subjects into the experimental group, which uses CALL, and the control group, or the traditional way of teaching. In Task #3, the experimental group outperformed the control group by a significant score of 78.20% against the latter's 72.13%, that is, a difference of 6.07% between them. On average, the experimental group enhanced their scores by 9.80% in three assessments, while the control group did so by 3.76%. It can thus be inferred from this that the integration of CALL indeed facilitates improvement in the ability to write and enables students to rise above their peers even on subsequent tasks. While the limited integration of technology in English language teaching was indeed confirmed, the study showed that if the students are given chances to extend their learning out of class, then the development in their writing skills is substantial. This points out that CALL could be a real tool to enhance deeper understanding and mastery in writing among EFL learners [36].

In conclusion, these studies collectively demonstrate the positive effects of CALL on various language skills. However, some gaps and limitations call for further investigation. Future research should explore specific features and types of CALL applications for different writing genres, examine individual differences in learners' responses to CALL, and include larger and more diverse samples. Addressing these gaps will contribute to a more comprehensive understanding of the benefits and optimal implementation of CALL in language instruction.

Method

Participants

The study adopted a mixed-methods design to delve into the effect of CALL and non-CALL integrated assessment on Iranian EFL learners' summary writing ability. The present study consisted of two intact classes, comprising intermediate-level English as a Foreign Language learners. The Oxford Quick Placement Test (QOPT) and University of Cambridge Local Examinations Syndicate were administered to 57 Iranian EFL learners. The test was accessible online and in the in-person classes. To participate, the participants had to score between 30 to 39 out of 60 on a general English test. The placement test showed that only 40 participants were qualified as intermediate in their language proficiency. Participants for the non-CALL classes were from Qom, while participants for the CALL classes were from different cities. In addition, most of the participants were English learners; most of them were even English teachers. The last sample was randomly divided into an integrated assessment group and a non-integrated assessment group, with 10 students in each subgroup. The sample included male and female students, aged between 20 and 32 years old, who were native speakers of Farsi. Table 3.1 presents the demographic characteristics of these teachers.

Instruments

The Oxford Quick Placement Test

One such tool was the Quick Oxford Placement Test, as adapted by Smith & O'Leary 2014, which was a well-established standardized test with acceptable levels of validity and reliability. This form of testing would normalize the students and provide a measure of the students' current levels of language proficiency. This comprised, in all, 65 items in multiple-choice format. Of these, 15 items tested vocabulary, 20 grammar, and 30 were cloze tests. This test was used by the experimenters to reach a common base among the subjects and measure their language abilities correctly.

Table 1: Demographic Information of the Participants

	Categories	N
Gender	Male	24
	Female	16
Age	20-22	8
	23-25	10
	26-28	9
	29-31	7
	32-34	6
Years of Learning Engli	3-7	19
	More than 7	21

The Select Readings Book (Intermediate Level)

The books entitled Select Readings were used in order to effectively carry out the instructional techniques of summary writing. Passages of equal difficulty were selected with various techniques of summary writing. These books acted as a milestone in our exploration of summary writing techniques and proved to be invaluable. We could use the content from these books to effectively apply and practice the prescribed instructional techniques. Compiled by Lee and Gundersen, the Select Readings series gives reading books for different levels of proficiency: low, intermediate, upper-intermediate, and advanced. What is more important, each one of these books displays a firm grounding in level control and great entertaining passages.

The TOEFL-iBT Scoring Guidelines

The TOEFL-iBT scoring guidelines that the researchers used to measure the performance of the learners in summary writing were the same guidelines employed by Baba (2009) in his study. The TOEFL-iBT Scoring Guidelines provide a uniform rubric for evaluating participants' writing ability from the performance on a summary writing task. These criteria were used to score the participants' writing skills on the coherence and organization of the summary, vocabulary and grammar used, and overall effectiveness of writing.

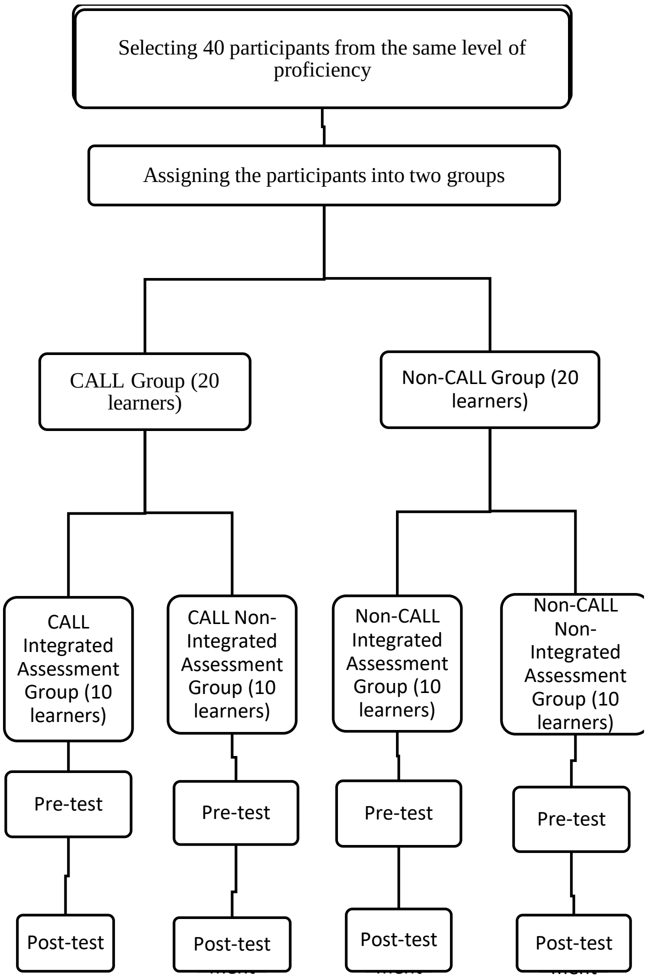

Fig. 1. The Process of Data Collection

Semi-Structured Interview

A semi-structured interview is a research method that allows for open-ended questions and follow-up questions to explore participants' experiences, attitudes, beliefs, and perceptions related to a specific topic (Rubin & Babbie, 2017). A semi-structured interview was conducted to get qualitative data on their experiences with summary writing and their perceptions of integrated assessment as a means of enhancing their writing abilities.

Self-Assessment Report

A valuable instrument called a self-assessment report was incorporated. The design of this report was based on Nunan's template [37]. Its purpose was to enable students to track their weekly progress and development throughout the course. The self-assessment report encompassed various essential elements, including a reflection on the topics covered and learned during the week, an evaluation of the students' writing skills in terms of organization, content, language usage, and task fulfillment. It also provided an opportunity for students to identify their mistakes, highlight areas of difficulty, specify their learning preferences, and outline future learning plans. The comprehensive explanation of the self-assessment report was provided to the students, and the teacher demonstrated its usage in several instances to ensure clarity and understanding. Before its implementation in the main study, the self-assessment report underwent a pilot test phase to assess its validity. This involved seeking feedback from two Applied Linguistics professors from Lorestan University, who evaluated the report's face and content validity, ultimately confirming its suitability for the study. Furthermore, the report's items were refined based on insights gathered from five grade 11 students who were asked to write on a given topic and provide feedback on any areas of ambiguity. Consequently, adjustments were made to enhance the report's language and usability in the research context.

Data Collection Procedure

Before the courses began, participants had consented, and researchers did not allow them to leave unprepared. They outlined all about the research being designed to point out the reason, manner, and merits accruable by improving their performance at places of work and staying well. They were mailed an audio attachment to illustrate that, through involvement in language learning, this participation meant something. The researchers were aware of any issue that could arise and assured participants at all times that they might withdraw from the research process, highlighting how their participation was entirely on a volunteer basis. These approaches guaranteed strict confidentiality and privacy of information, based on the principle of keeping the participants' responses and personal data well-guarded. As a result, the conditions helped gain trust and freedom among the respondents to provide their experiences and views openly.

The research will be qualitative and quantitative. Qualitative analysis is used to examine the participants' responses to open-ended questions, identify themes, and extract relevant information. Closed-ended questions will be analyzed statistically in order of significance. The merging of these two methods by the researchers aims at a complete understanding of the participants about their technological proficiency and experiences during the study. The researchers hope that the results of this study will be helpful in informing future practices and interventions in education. Their tech literacy will help in finding out areas that might need support and training. This could be useful in guiding targeted resources and workshops to improve technology literacy among teachers and students. Researchers look to the improvement of the educational experience concerning the given technology challenges and the better digital skills of the participants.

Non-CALL Non-Integrated Assessment

The non-computer-assisted language learning, not integrated assessment classes, required four sessions after a pretest. These classes had been designed to help the students improve their summary writing skills with various techniques, along with activities. The main resource book for these sessions was "Select Reading." During each of the sessions, the students summarily wrote about different techniques. This was to equip students with the knowledge of effective summarization of texts while developing their writing skills. The sessions were organized in such a way that the student`s skills in summarizing materials started improving gradually. The study was assisted by the book "Select Reading"; every session was based on different readings of the chapters from that book. In that perspective, homework was the medium used by the researcher from the students in conducting an effective data collection method. They were required to read an additional chapter from the book and make a summary using the technique learnt in the session. In this approach, students had to individually practice and reinforce the learned techniques of summary writing. As these classes were not integrated with assessment, the activities were different from the integrated assistant class. In these non-evaluation classes, a supportive learning environment was ensured without incorporating formal evaluation methods such as peer assessment, self-access, self-evaluation, or reflection. However, the researchers conducted a final exam in order to test the students' overall understanding and progress. Another important feature was the interactive quizzes given to reinforce the summary writing skills learned in the sessions. These quizzes were made up of various question formats, including multiple-choice, fill-in-the-blanks, and matching exercises. The quizzes were designed to encourage students to arrange statements correctly and provide instant feedback to help them refine their summarization skills.

Consequently, the instrumentation in my non-computer-assisted language learning, non-integrated assessment classes took the form of four sessions designed to enhance the summary writing skills of students. The readings alone were the source of information; that is, one session equated to one chapter. The instrumentation contained summary writing, error analysis, summary paraphrasing, quizzes, and fill-in-the-blank exercises. The classes didn't involve peer assessment, self-access, self-evaluation, or reflection components, but the experimenters administered a final test to assess the overall achievement of the students. Students provided feedback on their summaries, mistakes, and suggestions for improvement. The structured nature of the sessions allowed students to first improve and then refine their summary writing.

CALL Non-Integrated Assessment

In the CALL non-integrated assessment classes, the students were continuously developed in their summary writing skills through various activities. The classes were held on the platform of Adobe Connect, thus giving the students a more dynamic and interactive environment for learning. Technology was employed to increase the level of student engagement and to facilitate efficient communication between the instructor and learners. The activities for the CALL non-integrated assessment classes were again similar to the previous class, namely, summary writing, error analysis, summary paraphrasing, quizzes, and fill-in-the-blank exercises. However, technology made them more accessible and enjoyable to the students.

Students were asked to write summaries as emails and submit them to the instructor for their homework assignments. Assignments are easy to submit this way and to track. The instructor provided the feedback by recording audio messages and sending them back. The personal approach of giving feedback not only allowed for the timely delivery of the feedback but also resulted in an interactive and more engaging learning process for the students. Computer-assisted language learning non-integrated assessment classes still maintained quizzes and tests as a part of the assessment. To make the assessments more interactive, the assessment was made using the 'Poll Box' feature on the Adobe Connect platform. This enables the instructor to include engaging quizzes and tests that the students can participate in during the live sessions. Real-time feedback and immediate results through the Poll Box feature allowed for friendly competition and excitement among the students. In these classes, most activities were to be done individually in breakout rooms. Breakout rooms in Adobe Connect facilitated collaborative and interactive learning experiences. Then, students were divided into breakout rooms, where they had the chance to work independently on the activities. This led to focused engagement and active participation. The instructor moved from breakout room to breakout room to give each student personalized feedback and guidance. This approach guaranteed personalized attention and created an interactive and supportive learning environment.

The results of the non-integrated assessment classes in the computer-assisted learning mode of languages were nothing less than astonishing. Putting the children on technology, with all its various activities and individual performance feedback, brought forth phenomenal progress in the summary writing of students. Interactive quizzes, breakout rooms for group activities, and timely feedback-all these made up an environment where every participant wanted to participate with maximum zeal. The progress and achievements of the students far exceeded expectations, with amazing outcomes that left everyone involved dumbfounded.

Non-CALL Integrated Assessment

The researchers applied an integrated model to improve students' writing summary skills in my non-computer-assisted integrated language learning assistant classes by using rubric criteria, metacognitive questions, peer assessment, self-evaluation, self-reflection, and self-assessment. First, the instructor explained a detailed rubric in class. The rubric specified the characteristics of what constitutes a good summary and included aspects such as content, organization, coherence, and grammar. By giving the students this kind of rubric, this instructor gave students a mandate to self-assess work and understand standards met and unmet.

The instructor developed my students' metacognitive skills in summary writing by incorporating a series of thought-provoking metacognitive questions. Before they started writing, the instructor asked my students to consider questions such as: "What is the purpose of your summary?" This question helped my students understand the goal of summarizing, which is to condense and convey the main ideas of the original text concisely. "What do you do to get the main ideas of the original text?" This question invited the students to reflect on effective reading strategies such as skimming, scanning, and identifying key information.

While the students were writing, the instructor encouraged them to engage in metacognitive reflection by asking questions such as: "How will you ensure that your summary is concise and effectively captures the key points of the original text?" This question prompted them to consider the importance of conciseness and the need to prioritize the most relevant information. Another metacognitive question the instructor posed to them was: "Are you monitoring the clarity and coherence of your summary as you write and making necessary adjustments?" This question reminded them to continuously self-monitor and revise their summaries to ensure coherence and logical flow. Peer assessment played a vital role in my non-computer-assisted language learning integrated assistant classes. The participants exchanged summaries and provided constructive critiques during the peer feedback session. The instructor guided this with guidelines for peer assessment that included, among others, content accuracy, coherence of organization, language, and adherence to the requirements as stated in the rubric. This peer review process allowed students not only to receive multiple points of view and insights but also to be motivated to make their own judgments based on the feedback they received. In commenting constructively on their peers' summaries, students also learned to develop their critical thinking skills and built a deeper understanding of what a good summary should be.

Results and Findings

Testing Assumptions

The remaining five assumptions related to One-Way Analysis of Covariance (ANCOVA) will be covered in this section. First, inter-rater reliability indices were computed for the pretest and posttest of summary writing. As shown in Table 4.1, there was significant agreement between the two raters on the pretest (r (38) = .779 representing a large effect size, $p < .05$), and posttest (r (38) = .916 representing a large effect size, $p < .05$) of summary writing.

Table 2: Pearson Correlations for Inter-Rater Reliability Indices

		Pretest Rater2	Posttest Rater2
Pretest Rater1	Pearson Correlation	.779**	
	Sig. (2-tailed)	.000	
	N	40	
Posttest Rater1	Pearson Correlation		.916**
	Sig. (2-tailed)		.000
	N		40

The collected data should not show any significant deviation from normality; i.e., the second assumption. Table 3 shows the skewness and kurtosis indices and their ratios over the standard errors. As shown in Table 3, the computed ratios were lower than ±1.96. Thus, it was concluded that the assumption of normality was retained.

Table 3: Skewness and Kurtosis Indices of Normality

Group		N	Skewness		Kurtosis		Ratio	
		Statistic	Statistic	Std. Error	Statistic	Std. Error	Skewness	Kurtosis
CALL Integrated	Pretest	10	.328	.687	-1.196	1.334	0.48	-0.90
	Posttest	10	-.205	.687	.013	1.334	-0.30	0.01
CALL Non-Integrated	Pretest	10	-.232	.687	-.586	1.334	-0.34	-0.44
	Posttest	10	.144	.687	-1.754	1.334	0.21	-1.31
Non-CALL Integrated	Pretest	10	-.233	.687	-1.001	1.334	-0.34	-0.75
	Posttest	10	.234	.687	-1.007	1.334	0.34	-0.75
Non-CALL Non-Integrated	Pretest	10	.233	.687	-.369	1.334	0.34	-0.28
	Posttest	10	.101	.687	-.011	1.334	0.15	-0.01

One-way ANCOVA assumes homogeneity of variances of the groups. The significant results of Levene's tests (F (3, 36) = 3.39, p < .05) (Table 4.3) indicated that the assumption of homogeneity of variances was not retained. There is no need to worry about the violation of this assumption.

Table 4: Levene's Test of Homogeneity of Variances for Posttest of Summary Writing by Groups with Pretest

F	df1	df2	Sig.
3.391	3	36	.028

One-way ANCOVA requires that there be a linear relationship between the pretest and posttest of summary writing. The significant results of the linearity test (F (1, 39) = 33.54, p < .05, eta squared = .424 represent a large effect size) (Table 5).

Table 5: Levene's Test of Homogeneity of Variances for Posttest of Summary Writing by Groups with Pretest

			Sum of Squares	df	Mean Square	F	Sig.
Posttest * Pretest	Between Groups	(Combined)	87.660	15	5.844	1.177	.350
		Linearity	33.540	1	33.540	6.758	.016
		Deviation from Linearity	54.120	14	3.866	.779	.681
	Within Groups		119.115	24	4.963		
	Total		206.775	39			
	Eta Squared		.424				

One-Way ANCOVA requires that there should be linear relationships between pretest and posttest of summary writing across the four groups; i.e., homogeneity of regression slopes (Table 6). The non-significant interaction between covariate (pretest) and the independent variable (F (3, 32) = 1.13, p > .05, Partial eta squared = .096 represents a moderate effect size) indicated that the statistical assumption that the relationships between pretest and posttest of summary writing were linear across the four groups was supported.

Table 6: Testing Homogeneity of Regression Slopes Posttest of Summary Writing by Groups with Pretest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group	2.923	3	.974	3.919	.017	.269
Pretest	29.714	1	29.714	119.523	.000	.789
Group * Pretest	.847	3	.282	1.136	.349	.096
Error	7.955	32	.249			
Total	9878.875	40				

Answering the Questions

Table 7 shows the four groups' means on the posttest of summary writing after controlling for the effect of the pretest. The results showed that the CALL integrated group (M = 17.62, SE = .159) had the highest mean on posttest of summary writing after controlling for the effect of pretest. This was followed by CALL non-integrated (M = 16.44, SE = .160), NON-CALL integrated (M = 15.93, SE = .159), and NON-CALL non-integrated (M = 12.20, SE = .159) groups.

Table 7: Descriptive Statistics for Posttest of Summary Writing by Groups with Pretest

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
CALL Integrated	17.627[a]	.159	17.304	17.950
CALL Non-Integrated	16.440[a]	.160	16.115	16.765
Non-CALL Integrated	15.930[a]	.159	15.608	16.252
Non-CALL Non-Integrated	12.203[a]	.159	11.881	12.526

Table 8 shows the main results of One-Way ANCOVA. The results (F (3, 35) = 217.93, p < .05, partial η^2 = .949, representing a large effect size) indicated that there were significant differences between the four groups' means on the posttest of summary writing after controlling for the effect of the pretest.

Table 8: Tests of Between-Subjects Effects for Posttest of Summary Writing by Groups with Pretest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Pretest	29.547	1	29.547	117.483	.000	.770
Group	164.432	3	54.811	217.932	.000	.949
Error	8.803	35	.252			
Total	9878.875	40				

The significant results of One-Way ANCOVA were followed by Bonferroni post-hoc comparison tests (Table 9 to Table 14).

Question 1

The CALL integrated group (M = 17.62) significantly outperformed the non-CALL integrated assessment group (M = 15.93) on the posttest of summary writing after controlling for the effect of pretest (MD = 1.69, p < .05) (Table 9).

Table 9: Bonferroni Post-Hoc Comparison Tests for Comparing CALL-Integrated and Non-CALL-Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CALL Integrated	Non-CALL Integrated	1.697*	.225	.000	1.069	2.326

Question 2

The CALL non-integrated group (M = 16.44) significantly outperformed the non-CALL non-integrated assessment group (M = 12.20) on the posttest of summary writing after controlling for the effect of pretest (MD = 4.23, $p < .05$) (Table 10).

Table 10: Bonferroni Post-Hoc Comparison Tests for Comparing CALL Non-Integrated and Non-CALL Non-Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CALL Non-Integrated	Non-CALL Non-Integrated	4.237*	.226	.000	3.605	4.869

Question 3

There was no significant difference between the CALL non-integrated group (M = 16.44) and the non-CALL integrated assessment group (M = 15.93) on the posttest of summary writing after controlling for the effect of the pretest (MD = .511, $p > .05$) (Table 11).

Table 11: Bonferroni Post-Hoc Comparison Tests for Comparing CALL Non-Integrated and Non-CALL Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CALL Non-Integrated	Non-CALL Integrated	.511	.225	.178	-.120	1.141

Question 4

The CALL integrated group (M = 17.62) significantly outperformed the non-CALL non-integrated assessment group (M = 12.20) on the posttest of summary writing after controlling for the effect of pretest (MD = 5.42, $p < .05$) (Table 12).

Table 12: Bonferroni Post-Hoc Comparison Tests for Comparing CALL Integrated and Non-CALL Non-Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CALL Integrated	Non-CALL Non-Integrated	5.424*	.224	.000	4.796	6.051

Question 5

The CALL integrated group (M = 17.62) significantly outperformed the CALL non-integrated assessment group (M = 16.44) on the posttest of summary writing after controlling for the effect of pretest (MD = 1.18, $p < .05$) (Table 13).

Table 13: Bonferroni Post-Hoc Comparison Tests for Comparing CALL Integrated and CALL Non-Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CALL Integrated	CALL Non-Integrated	1.187*	.227	.000	.551	1.822

Question 6

The NON-CALL integrated group (M = 15.93) significantly outperformed the NON-CALL non-integrated assessment group (M = 12.20) on the posttest of summary writing after controlling for the effect of pretest (MD = 3.72, $p < .05$). Figure 2 shows the four groups' means on posttest of summary writing after controlling for the effect of pretest (Table 14).

Table 14: Bonferroni Post-Hoc Comparison Tests for Comparing Non-CALL Integrated and Non-CALL Non-Integrated

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Non-CALL Integrated	Non-CALL Non-Integrated	3.726*	.224	.000	3.099	4.354

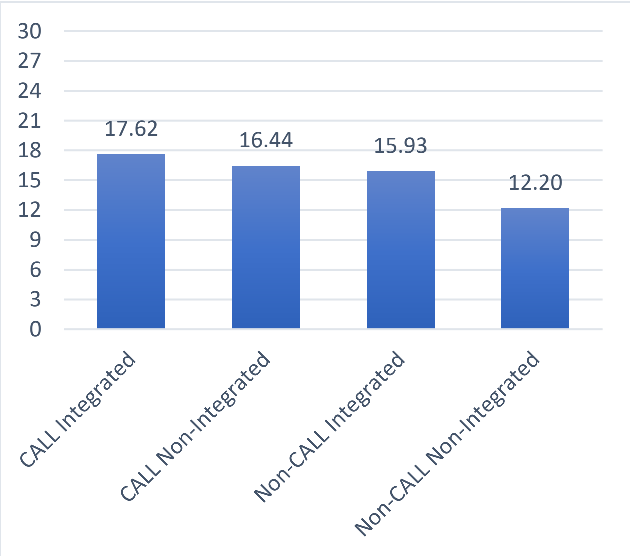

Fig. 2. Means On Posttest of Summary Writing by Groups with Pretest

Question 7

The participants mentioned the constraints and challenges they faced during the CALL-integrated class. They highlight technical issues, limited access to technology, the need to develop digital literacy skills, language barriers, individual learning preferences, time management challenges, and the lack of immediate instructor support. Furthermore, they emphasize the instructor's ability to adapt the learning style to address individual learning preferences and engage them effectively. The participants acknowledged the comprehensive support, clear instructions, and accessible resources provided by the instructor and the institution in overcoming these constraints and challenges. They also emphasize the transformative nature of the experience, the enhancement of language proficiency, and the acquisition of valuable digital literacy skills.

Participant 1: "The CALL-integrated class was an exceptional learning experience that exceeded our expectations. Technology, online platforms, and digital tools made it possible to learn a new language. Interactive activities gave us immediate feedback, enabling us to practice and improve our language skills with precision. Technology not only prepared us for the digital future but also provided us with valuable digital literacy skills that are now highly valued in the 21st century. The seamless integration of technology and language learning was incredibly empowering."

Participant 2: "The CALL-integrated class was a captivating and engaging learning experience that kept us engaged from the outset. Technology enabled us to have highly personal learning experiences, tailored to our individual interests and needs. Using collaborative tools and online resources, we were able to build a sense of belonging among our peers, connect with each other, and learn from each other with ease. Technology has given us the skills for future language learning and digital native skills for the job."

Participant 3: "We were exposed to a world of language learning opportunities through the CALL-integrated class. Interactive activities and multimedia resources made complex language concepts accessible and comprehensible. Technology allowed us to work with others without a problem, learn from our classmates, and get immediate feedback that significantly improved our language proficiency. The impact of this experience, and the transformation that it has brought, is that it highlights the transformative and immense benefits of integrating technology into language learning."

Participant 4: "We had to take a class called integrated, and it was a revelation of knowledge. We had technical problems, glitches, compatibility issues with online platforms, and software. Technology also hindered some of us from engaging and participating. And the process of becoming a digital liar was a tough one; we had to use and navigate a range of digital tools and platforms. Language barriers made it harder to understand instructions and interact with digital resources during our learning. The reward is a dreamlike flower that we work very hard to obtain in many areas in order to motivate ourselves. However, our teacher was able to adjust his teaching style to motivate us with remarkable ease and thus make his teaching more meaningful. We struggled with managing time for online activities, assignments, and self-study, but the instructor and institution provided us with ample resources and made it easy to access materials when needed. This has helped us with our language skills and digital literacy skills."

Participant 5: "The CALL-integrated class changed our language learning path and changed our language learning. We had to learn to use computers, the Internet, and software compatibility issues, etc. We didn't get to go to class and we didn't get to go to class. Besides, the process of becoming literate online was a significant challenge due to the variety of media we were exposed to. Language barriers made it harder to understand instructions and use technology. Besides, we all learn differently and may not be able to get the same things in class, which leads to less motivation. Despite everything, our instructor's exceptional adaptability and expertise allowed them to truly alter the learning approach, adjusting it to our requirements and engaging us thoroughly. We struggled with managing time for online activities, assignments, and self-study, but the instructor and institution provided us with comprehensive guidance, accessible resources, and efficient support. This has helped us learn a lot of languages and given us the digital literacy we need to live our lives."

Groups on Pretest

Table 15 shows the results of the One-Way analysis of variance (ANOVA) on the pretest of summary writing. The results (F (3, 36) = .342, p > .05) indicated that there were no significant differences between groups' means on the pretest of summary writing. The four groups' means on the pretest were 11.05, 11.57, 11.25, and 11.15.

Table 15: One-Way ANOVA for Pretest of Summary Writing by Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.555	3	.518	.342	.795
Within Groups	54.506	36	1.514		
Total	56.061	39			

Discussion

Whereas both combined experiments yield a few key differences in the groups, posttest results showed the non-CALL nonintegrated group performed better than the CALL nonintegrated group, with the CALL approach improving this ability to write summaries. It was also found that the CALL-integrated group significantly outperformed the non-CALL non-integrated group and the CALL-integrated group, indicating the added value of including assessment in the CALL approach. There is no statistically significant difference between the non-CALL integrated group and the non-integrated one. Findings point to the very important fact that the integration of technology and integrated assessment has the potential to enhance the practice of giving EFL writing instructions. This is because the features involved in CALL result in more interactive learning and increased learners' involvement.

The present study, along with Zaghlool [38], finds the encouraging attitudes of university EFL learners toward CALL online writing activities helpful, motivating, and enjoyable since they allow access at all times and from anywhere. This research also verifies that there is a positive attitude toward the integration of CALL online writing activities in writing instruction. Integration of assessment provides the learners with on-time feedback, enabling their language development. From the above, it is evident how the CALL-based practices and measures added value to the ESL students' written expression in enhancing their learning process. These findings were further corroborated by the qualitative investigation into the error patterns and samples of writing through the delineation of areas where improvement needed to be made in students.

The identified issues regarding coherence, organization, lexical use, and grammar helped provide information that contributed to conducting instructional interventions and giving individual feedback. In addition to the quantitative and qualitative analyses, the current study also prepared a questionnaire related to perceptions and attitudes of the participants toward different types of instructional approaches. The open-ended type of question and Likert scale items allowed the respondents to present their opinions and also give some feedback regarding their learning experience. Indeed, most people in the CALL and non-CALL groups described the teaching methodologies as favorable; the technology-enhanced telephone approach kept them more interested and motivated than the simple traditional uncalled group; activities of CALLs were interactive by participants themselves; there is an appreciation of the immediate feedback from the computer programmers. Those who participated in the CALL integrated group also welcomed the assessment featured in the learning process. Through regular critique and feedback, it provided them with a way of pinpointing their strengths and weaknesses in summary writing. The information like that paved the way to spot aspects that needed improvement and monitor progress over time. Less problematic features for them were the inability of teaching activities to present as many instances of interactivity as well as the lack of variation. They said that the method somehow limits their opportunities for practice and participation in using it. Yet, there were some voices in a non-CALL group expressing favor when speaking about simplicity and familiar structure on the traditional classroom site.

A follow-up questionnaire and interview were also used to gauge things like pre-computer literacy, language acquisition strategies, and motivation. Results indicated that the CALL approach benefited students with greater computer skills and greater self-management skills. This is because such students are in a better position to utilize the interactive features of the CALL programs. Students who had never used a computer before had some initial difficulties with the CALL process.

Nevertheless, these hurdles were overcome, and they made full use of the technology-based learning environment. The research also analyzed the teacher's role in these varying approaches to instruction. For interviewing the teachers of English in charge of the sessions, their opinions have been presented. As the approach of CALL has evidenced in the words of teachers themselves, it made them more personalized, turning them into better mentors and facilitators. CALL programs made tracking and providing feedback easier for students. On the other hand, there is a need to weigh technology use with authentic face-to-face interaction and classroom activity. CALL, an integrated assessment, has been applied to improve summary writing skills of EFL learners at the intermediate level.

The research showed that with intervention, the CALL approach and assessment significantly enhanced the improvement in learners' ability. A technology-rich learning environment nurtures engagement and interaction and fosters immediate feedback, impacting positively upon learner motivation and success. This is reflected in a study by Mathews-Aydinli and Elazi [11], which found that teachers believed their students were more motivated during interactive whiteboard (IWB) lessons. Turkish EFL students and teachers also reported positive attitudes toward this technology, feeling comfortable and recognizing its effectiveness.

Its implications can also be exploited by practitioners for their particular needs in their classroom teaching practices and the language-learning environments. Non-CALL integrated assessment is an approach that would enhance the students' language through various approaches. Rubrics, metacognitive questions, peer review, and self-assessment are all important components of this approach that help students develop their language skills. Integrated assessment that involves non-CALL; the main focus would revolve around rubrics.

They provide clear-cut guidelines and specifications as to what proficient writing means. This enables the student to independently review his or her work. The rubric helps the student point out his strengths and weaknesses as a writer, which in turn helps him upgrade his language. Also, elements such as grammar, coherence, organization, vocabulary usage, and ability of critical thinking have been highlighted on writing rubrics. One of the distinctive features of the non-CALL-integrated assessment approach is the metacognitive questions. These questions get students thinking about writing. Students can think about the purpose of writing, the methods used, clarity of ideas, and effectiveness of communication, among other aspects. This is a tool that can be used by students to get insight into their own learning and developing writing skills through metacognitive reflection. The non-CALL integrated assessment approach makes use of peer evaluation as an effective tool. The student is allowed to comment on the work of others. This peer assessment method provides the writer not only with a means to evaluate a composition but also gives rise to shared learning. The acquisition of writing styles, ways, and tactics amongst the students is of use to the overall language learning. Peer counseling also makes students think critically by examining other students' work, criticizing constructively as well, and taking part in constructive dialogues. Integrated assessment approach for non-CALL involves self-assessment.

It also provides students with the opportunity to reflect on their own writing, considering their progress, strengths, and weaknesses. This encourages students to take responsibility for their language learning, allowing them to personalize their approach. By setting targets and monitoring their progress over time, students enhance their motivation. This aligns with insights from Pinner [33], who highlights the significant relationship between student and teacher motivation, noting that students' perceptions of computer-assisted language learning (CALL) can greatly influence their engagement and decision-making.

Reflection upon writing skills enhances students' self-awareness and proactive attitude in language learning. The non-integrated approach mainly aims at writing proficiency but, in effect, boosts vocabulary acquisition. It is through writing that the students can interrogate various texts and pick out information relevant to their needs. Their vocabulary becomes developed through reading of many texts because the new words and phrases find their way into writing. Students are also bound to choose appropriate vocabulary while attempting to summarize information and express ideas, which leads to new vocabulary. The non-CALL integrated assessment method helps students develop critical thinking skills through metacognitive questions about their purpose, strategy, and clarity in their work. However, this approach differs from the findings of Al-Mansour and Al-Shorman [32], who examine the effects of computer-assisted instruction on Saudi university students' English learning. Their study suggests that using technology alongside traditional teaching methods leads to better student achievement. This shows a contrast between focusing on assessment without technology and integrating technology to enhance learning. Moreover, peer assessment and collaborative group activities help students critically evaluate and give constructive feedback on peer work, thereby fostering critical thinking. This will also help the students in thinking more critically and help them to write with confidence. They can also develop the ability to think critically about their own work and that of others, and enhance their critical thinking skills, which are helpful in language development. The non-CALL integrated assessment approach also recognizes the need for providing constructive feedback to students. Feedback allows students to make improvements in their language and writing growth. In addition, feedback is not confined to instructor feedback but also involves peer feedback and self-reflection. This kind of feedback coming from different sources enables the student to understand better where his or her strengths and weaknesses are, observe patterns in their writing, fix problems, and focus on specific areas of improvement.

Conclusions

The non-CALL classes were not tech-intensive, but some students showed interest in the possible benefits of integrating technology into, for example, computer-assisted language learning CALL classes. They realized the benefits and opportunities that technology brings about in enhancing teaching, facilitating interactive activities, and creating an immersive and interactive language learning environment. Good, non-CALL classes were face-to-face interaction; still, a great understanding exists that the role of technology has to be encouraged for enhanced language learning, engagement, interaction, and language development. Overall, the preliminary results of some points about the current situation of CALL and non-CALL integrated assessment methods within an EFL learning class pedagogically involve instructional practice, curriculum design, and assessment strategy implications, especially regarding teaching summary writing.

Individualized Instruction: CALL integrated assessments allow for individualized instruction. In this case, teachers can use technology to help students by offering immediate feedback regarding the specific areas that the students need to work on in summary writing. The personal nature of such feedback makes it easier for the students to realize their points of strength and weakness.

Timely Feedback: Summary writing is one of the skills that really require feedback, both CALL and non-CALL. The students can get immediate feedback regarding their summaries and thus give a second look at their writing to make modifications. The feedback will be on time to keep the students learning and writing a summary.

Authentic Writing Practice: Integration of technology in CALL assessments has facilitated the students to get authentic writing practice opportunities. For example, students can use online activities or any writing software to summarize something in contexts similar to real-life situations. This type of authentic practice will help in enhancing the student's skills to summarize different types of texts appropriately.

Cooperative Learning: Non-CALL integrated assessment, especially face-to-face interaction, can enhance cooperative learning in summary writing. It is feasible that the teacher designs group activities to let students cooperate to summarize the texts and give feedback to peers. In this way, critical thinking ability is promoted, and peer learning and classroom coexistence are encouraged.

Integrated Language Skills: The language skills in summary writing can be gauged by the CALL-integrated assessments and the non-CALL-integrated assessments. In these, the writing skill, reading comprehension, vocabulary, and grammatical proficiency of the students can be brought out. The integrated approach goes well with the overall nature of language learning itself and helps develop a raft of language skills.

Curriculum Design: The findings of this study can be used to enhance the design of the curriculum by underlining the need for both CALL and non-CALL integrated assessment methods to be included throughout the EFL learning curriculum at appropriate times. This balance, in fact, brings a balance between technology-enhanced assessment and face-to-face interactions for a holistic learning experience and caters to diverse learning preferences and needs.

Formative Assessment: CALL and non-CALL integrated assessment methods can be used formatively to inform instructional practices. Results of the assessment will help the educator to identify areas where students need extra support, adjust their teaching methods, and apply targeted interventions to enhance their summary writing skills. Pedagogical implications can play a very significant role in teaching and learning summary writing in EFL contexts.

The limitations of the present research were significant. Firstly, self-flattery syndrome might have caused the biased conclusion because researchers often subconsciously emphasize their work in a positive light. The reactive effect most likely impacted subject behavior, as awareness of being studied could have altered subject responses and compromised data veracity. Besides, generalizing findings was limited because they can only be applied to specific circumstances and a sample population. The small sample size constrained statistical power and reliability, making definitive conclusions challenging. Finally, the cost imposed on the researcher restricted the study's scope, as limited funding hindered comprehensive data collection and analysis. These factors necessitated cautious interpretation of the results and indicated a need for further research.

Based on the current research and contributing to the field of integrated assessment methods in EFL summary writing instruction, several recommendations for future studies can be considered. A longer-lasting longitudinal study would provide valuable insights into the long-term impact of integrated assessment methods on EFL learners' summary writing skills, allowing the exploration of the sustainability of observed effects. It will, therefore, go a long way towards studying the effect of integrated methods of assessment across various levels of language proficiency. Therefore, inclusion of all the levels of language proficiency in the study would ensure that the interpretation for the different categories of learners is obtained. The approach can be mixed methods with more data collection techniques, such as observation or document analysis, which will give a fuller understanding of the experiences of the learners, integrated assessment in summary writing. This will be a far more complete understanding of the processes and mechanisms at play. Having a greater sample size, the research can be generalized, and the larger, more diverse sample would enhance research findings, allowing more sound conclusions on how well integrated assessment methods work.

Authors' Contribution

This research project was completed by Mr. Reza Shazdeh Ahmadi under the guidance and supervision of Dr. Reza Bagheri Nevisi at the University of Qom.

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Conflict of Interest

The authors declare no conflicts of interest

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