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Dear TOJDE Readers,

Welcome to Volume 25 Issue 3 of TOJDE

There are 16 articles in July 2024 issue. 57 authors from 8 different countries contributed to the issue. These countries are India, Indonesia, Kazakhstan, Malaysia, Qatar, Turkish Republic of Northern Cyprus, Turkiye and USA.

ARE ALARM BELLS RINGING IN ACADEMIA? CHATGPT AS A SAMPLE OF USING CHATBOTS IN EDUCATION is the title of the 1st article. Gurhan DURAK and Serkan CANKAYA are the authors. The main aim of this mixed methods study is to determine the evaluations made by academics on an academic text generated with ChatGPT and get their general views on ChatGPT. The convergent parallel design is utilized where the qualitative and quantitative methods are combined to produce triangulated results. Data were collected via an online form from 45 academics. Results are discussed at the end of the study.

The 2nd article is written by Irma DHITASARIFA and Indah Urwatin WUSQO. THE EFFECT OF STEAM APPROACH DIGITAL TEACHING MATERIALS ON INCREASING CREATIVE PROBLEM-SOLVING SKILLS is the title of the article. This study has a quasi-experimental research design with a nonequivalent control group. According to this study, it can be concluded that there is an effect of STEAM digital teaching materials to increase creative problem-solving skills.

The title of the 3rd article is PROVIDING EDUCATIONAL ACCESSIBILITY FOR A PARALYZED STUDENT BY EYE-TRACKING TECHNOLOGY: A DESIGN-BASED RESEARCH STUDY. Mehmet DONMEZ and Kursat CAGILTAY are the authors. This study explores the development of an eye-tracking solution for paralyzed students, enabling them to access and utilize personal computers for their education. The study followed four phases: problem analysis, solution development, evaluation, and documentation. This article highlights the potential of eye-tracking technology for paralyzed students and promotes the development of similar solutions.

INNOVATIONS IN ASSESSING STUDENTS' DIGITAL LITERACY SKILLS IN LEARNING SCIENCE: EFFECTIVE MULTIPLE CHOICE CLOSED-ENDED TESTS USING RASCH MODEL is the title of the 4th article, written by Fitria LAFIFA and Dadan ROSANA. This research goal to develop a multiple-choice closed-ended test to assessing and evaluate students' digital literacy skills. Data have been analyzed descriptively and inferentially using the Rasch version and the assist of Quest software. The results show that eight multiple-choice closed-ended test instruments are declared valid based on expert validation.

Zafer KADIRHAN and Mustafa SAT are the authors of the 5th article. K-12 TEACHERS' PERCEIVED EXPERIENCES WITH DISTANCE EDUCATION DURING THE COVID-19 PANDEMIC: A META-SYNTHESIS STUDY is the title of the study. This study explores the teaching experiences and opinions of K-12 teachers during the COVID-19 pandemic, focusing on challenges, advantages, and suggestions. Search queries were executed in leading databases (DergiPark, ULAKBIM TRDizin) to locate potential studies. Results of this study inform the development of evidence-based practices and policies that can support K–12 teachers in providing quality online education during times of crisis.

3D MODEL'S ONLINE MODULES EFFECTIVENESS IN PRACTICING MASTERY OF SOLAR SYSTEM CONCEPTUAL KNOWLEDGE is the 6th article. Dhanang Setyo ERVANA, RAHARJO, MUNASIR, Eko HARIYONO and Judhistira Aria UTAMA are the authors. This study aims to describe the 3D model's online modules effectiveness in the practicing mastery of conceptual knowledge in solar system learning using an instrument which tested 58 7th-grade respondents from one of the junior high schools in Jombang, East Java, Indonesia. Based on research results, learning the solar system using online modules with 3D models is better than using the official websites.

The title of the 7th article is ONLINE STUDENT ENGAGEMENT IN THE TURKISH CONTEXT: A PRISMA-BASED SYSTEMATIC REVIEW. This article is written by Handan ATUN, Dincer CINAR, Elif SENGUN OZTAS, Yasemin GULBAHAR, Sa'ad LAWS, Alan S. WEBER, Robert BIANCHI and Khawla

KITTANEH. This study investigated previously conducted research in chronological order on student engagement at the post-secondary level in the Turkish context using a PRISMA-based systematic review screening process. The results show that online engagement research and practices have clearly increased and diversified over time.

ACADEMIC DISHONESTY IN DISTANCE EDUCATION COURSES: A QUASI-EXPERIMENTAL STUDY is the title of the 8th article, written by Nayab IQBAL and Kaukab Abid AZHAR. This research study focuses on the growing concern of academic misconduct in distance education courses. A quasi-experimental study was conducted to measure the impact of introducing webcam recording software as an online supervision tool for high-stakes exams in two separate online courses (Management and Accounting). This study reveals online supervision is an effective tool to combat academic dishonesty in distance education courses.

The 9th article is titled LEARNING ANALYTICS FOR PERSONAL LEARNING ENVIRONMENTS: DETERMINING JOURNAL PUBLICATION TRENDS. The authors are Damla MUSTU YALDIZ, Saniye KULELI, Ozlem SOYDAN OKTAY, Nedime Selin COPGEVEN, Elif AKYOL EMMUNGIL, Yusuf YILDIRIM, Firat SOSUNCU and Mehmet FIRAT. According to the study, the e-learning domain has witnessed a shift from the traditional behavioral approach to an individual-centered learning approach based on learning analytics, with the aim of creating personalized and learner-sensitive designs. This study indicates that there is a potential to improve the fields of learning analytics and personal learning environments.

The authors of the 10th article are Mahfudzah OTHMAN, Aznoora OSMAN, Siti Zulaiha AHMAD and Natrah ABDULLAH. INTEGRATING SEGMENTING AND GAMIFICATION PRINCIPLES IN THE DESIGN OF INTERACTIVE GAMIFIED PROGRAMMING ASSESSMENTS FOR LOW ACHIEVERS is the title. This study discusses the design of interactive gamified assessments for an introductory programming course based on the multimedia segmenting principle and gamification. The objective is to develop more engaging online programming assessments for low-achieving students. The results reveal that all participants of this research agree with the usability recommendations integrated into the interactive gamified programming assessments.

AUTOMATED WRITING EVALUATION SYSTEM FOR FEEDBACK IN THE DIGITAL WORLD: AN ONLINE LEARNING OPPORTUNITY FOR ENGLISH AS A FOREIGN LANGUAGE STUDENTS is the 11th article. Hilal YILDIZ and S. Ipek KURU GONEN are the authors. This study aims to investigate the effectiveness of automated writing evaluation (AWE) feedback in error reduction in writing in English and the explore views of students regarding the utility of AWE tools. For this purpose, a total of 38 students at a university in Turkiye participated in the study, and three of their essays were evaluated. The findings of this study in general sheds light on using online digital tools of ubiquitous nature such as AWE to assist language improvement outside the class.

The title of the 12th article is A MIXED-METHODS STUDY OF SCHOOL LANGUAGE TEACHERS' TECHNOLOGY INTEGRATION: ARE THEY COMPETENCE WITH TPACK IN ONLINE LEARNING ENVIRONMENT? The authors are Nur Hanifah INSANI, SUWARNA and Sulis TRIYONO. The current study aims to explore the TPACK levels of Javanese school teachers, identify integrated technologies-based media used by Javanese school teachers in online learning practices and learning assessment, and analyze the benefits and drawbacks of Javanese school teachers integrating technology in online learning. The study suggests that policymakers facilitate Javanese school teachers to develop technological skills in transferring materials in online learning to support the current adapted curriculum.

Serap UGUR, Gokhan Deniz DINCER and Didem PASAOGLU BAS are the authors of the 13th article. The title of the study is AN EVALUATION OF THE MANAGERIAL CONTEXT FOR DIGITAL TRANSFORMATION IN THE CONTEXT OF OPEN EDUCATION IN HIGHER EDUCATION. This article examines the effects of technology in the field of education and management and focuses especially on the effects of technologies used in distance education activities on transformation processes. Based on

research conducted, the article explains how technological developments affect education and management processes, according to the findings obtained as a result of the interviews. As a result, the research emphasizes the need for further research and application to effectively use technologies such as artificial intelligence, blockchain, and metaverse in education and management processes. It is stated that advances in this field can cause significant transformations in education and management.

INTERCULTURAL USABILITY IN E-LEARNING OBJECTS PREPARED FOR TEACHING TURKISH TO FOREIGNERS is the 14th article. The authors are Burak SOZER, Nilgun OZDAMAR and Hulya PILANCI. This research investigates the intercultural usability factor of e-learning products designed for the instruction of Turkish as a foreign language. The subject of study, "Ana Dil Türkçe," refers to a freely accessible and distant education platform developed by Anadolu University with the purpose of instructing non-native speakers in the Turkish language. The findings indicate that the cultural learning objects inside the e-learning system are deemed adequate, albeit requiring further development and enrichment.

The authors of the 15th article are Ezgi DOGAN and Ferhan SAHIN. MAPPING THE RESEARCH AGENDA IN VIRTUAL REALITY STUDIES WITHIN EDUCATION is the title of the article. This systematic literature review (SLR) scrutinizes the trends and interrelationships prevalent in Virtual Reality (VR) applications within educational frameworks, analyzing a comprehensive pool of 43 theses conducted in a Eurasian country. The primary objectives encompass investigating learning-teaching theories, learning domains, design elements, VR typology, and the departments undertaking VR research. This research emphasizes the critical need for more comprehensive, theory-guided, and design-focused VR studies to propel its integration effectively within educational landscapes.

The 16th article is titled LEARNING LIFE SKILLS THROUGH MULTICULTURAL EXCHANGE: AN EXAMINATION OF PROSPECTIVE ENGLISH LANGUAGE TEACHERS' EXPERIENCES. Fahriye ALTINAY, Nesrin M. BAHCELERLI, Ramesh Chander SHARMA, Nurdan ATAMTURK, Zehra ALTINAY, Gokmen DAGLI and Mehmet ALTINAY are the authors. According to the study, the student exchange programs are venues for learning opportunities by offering multicultural contexts. This study reports on the experiences of ten prospective English language teachers in a virtual student exchange program to investigate likely skill development in a multicultural and open and distance learning setting. The study poses a few implications for education policymakers, curriculum developers, and teachers. In light of the results, it is posed that adding a multicultural aspect to the teacher training curriculum is imperative for teacher empowerment.

Hope to meet you in the next issue of TOJDE.

Cordially,

Dr. T. Volkan YUZER

Editor in Chief

ARE ALARM BELLS RINGING IN ACADEMIA? CHATGPT AS A SAMPLE OF USING CHATBOTS IN EDUCATION

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ABSTRACT

The main aim of this mixed methods study is to determine the evaluations made by academics on an academic text generated with ChatGPT and get their general views on ChatGPT. The convergent parallel design is utilized where the qualitative and quantitative methods are combined to produce triangulated results. Data were collected via an online form from 45 academics. Academics were asked to read and rate the sample text generated by ChatGPT. The titles "Writing rules," "Language and expression," and "Subject integrity" of the text generated by ChatGPT received the highest ratings from the academics. The qualitative findings obtained were interpreted within the framework of the "Diffusion of Innovations" and "Uses and Gratifications" theories, and the related themes were formed. As a result, the participants were asked about their feelings about using ChatGPT, and the themes of astonishment, pessimism, anxiety, and hopefulness emerged. Participants were asked their opinions about the benefits and negative aspects of using ChatGPT. Themes emerged under the benefits, and negative aspects titles were evaluated. Finally, the other themes that emerged under the satisfaction with ChatGPT and making ChatGPT widespread titles were assessed.

Keywords: Artificial intelligence, Chatbots in Education, ChatGPT, Diffusion of Innovations, Generative AI.

INTRODUCTION

Over the years, many chatbots have been released, like ELIZA in 1966, PARRY in 1972, Jabberwacky in 1988, Dr Sbaitso in 1992, ALICE in 195, SmarterChild in 2001, Siri in 2010, Google Assistant in 2012, Cortana in 2014, and Alexa in 2014. Although chatbots have been around for a while, users have only begun to notice them in recent years. This shift in recognition of chatbots and conversational interfaces mainly resulted from advancements in AI and machine learning and the rising use of messaging applications (Ina, 2022). ChatGPT is one of the chatbots launched by OpenAI on November 30, 2022. In a short time, it has gained tremendous popularity by being used by many people (Haleem et al., 2022).

G.P.T. ("Generative Pre-training Transformer") is a machine learning model developed by OpenAI. It is an extensive, deep neural network trained to generate natural language text that is coherent and similar to human writing. GPT models have achieved impressive results on various natural language processing tasks, including language translation, summarization, and question answering. It can generate human-like text and perform a wide range of language tasks. It is designed to understand and respond to natural language input and provide helpful and accurate information to users. ChatGPT is a sibling model to InstructGP and was fine-tuned from a model in the GPT-3.5 series, which finished training in early 2022 (OpenAI, 2022).

OpenAI's ChatGPT-3 is a state-of-the-art language processing AI model. One of the most extensive and advanced language processing AI models, it has 175 billion parameters. In addition to answering questions, composing essays and poetry, summarizing lengthy books, translating languages, conversing convincingly, and even creating computer code, GPT -3 can produce anything with a linguistic structure. Online text datasets were used to train the model. Over 45 TB of unfiltered text and 570 GB of filtered content from books, web texts, Wikipedia articles, and other online writings are included in the training. Three hundred billion words were entered into the system (Kumar, 2022). GPT-4, the most recent version of OpenAI's language model system, was formally released on March 13, 2023. Users may use the Chat GPT-4 tool with a premium membership. According to OpenAI, GPT-4 is more advanced in creativity, visual input, and longer context and surpasses ChatGPT in its advanced reasoning capabilities (OpenAI, 2023).

Using the same techniques as InstructGPT, ChatGPT was trained using Reinforcement Learning from Human Feedback (RLHF), with a few minor variations in the data configuration. Human AI trainers acted as users and AI assistants and provided conversations. Then, they ranked randomly selected model-written messages and sampled several alternative completions (OpenAI, 2022).

ChatGPT rarely can provide responses that are erroneous or illogical because(1) there is no source of truth during Reinforcement Learning training; (2) making the model more cautious makes it decline questions that it can answer correctly; (3) supervised training deceives the model. The model frequently can employ certain words and phrases excessively. These problems are due to over-optimization issues and biases in the training data (trainers favour lengthier replies that appear more comprehensive). When the user provides an uncertain query, the model should offer to clarify questions. Instead, the present model typically infers what the user means (OpenAI, 2022).

With the announcement of ChatGPT on November 30, 2022, ChatGPT gained people's attention immediately. Through social media, people talked about ChatGPT and shared the texts generated. Meanwhile, Figure 1 shows ChatGPT searches via Google Trends. With its announcement at the end of November, it has reached peak popularity (100%) in a very short time, which has caused quite a significant impact worldwide. The values indicate how many searches have been conducted for that particular term compared to the total number of searches performed on Google (Google News Initiative, 2019).

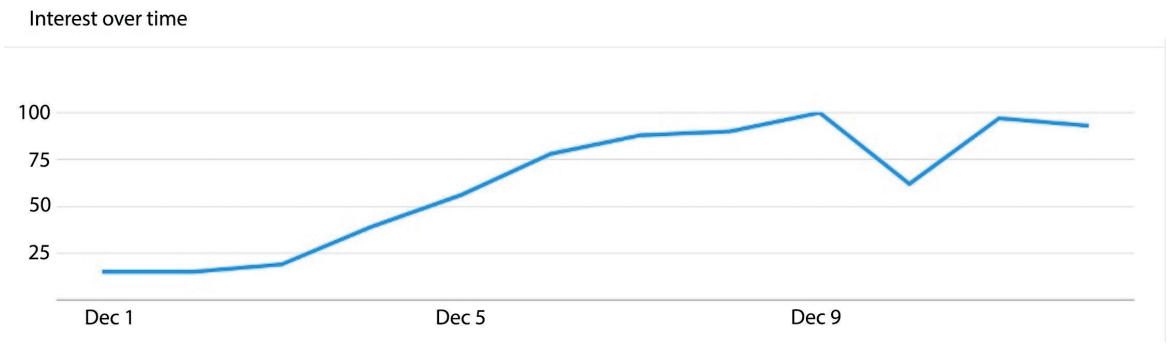

Figure 1. ChatGPT on Google Trends

The "interest by region" option has been selected to determine which regions this intense demand is high. According to Figure 2, this rate is 100% in China. Norway, Finland, Portugal, and Israel follow China.

Figure 2. Search Interests by Region About ChatGPT

Besides other skills, ChatGPT can be successful in academic writing. A good example is how ChatGPT can write an article's Introduction and Literature Review sections. It can enrich the text using citations, just like an academic article. On the other hand, it may not always provide accurate citations for the sources it uses to generate text (Donmez et al., 2023). Articles generated with ChatGPT will likely appear soon. This situation will bring about a change that concerns academic journals, editors, referees, and academicians. While ChatGPT can be helpful in academic writing, it can cause various concerns, such as ethics. Most people who publish, edit, and referee in academic journals are academics. So, ChatGPT's abilities, which is a new technology, in writing articles must be evaluated from various academic perspectives. As ChatGPT technology is relatively new, we have yet to find research evaluating the academic writing capabilities of ChatGPT through the lenses of academics. This study will fill an essential literature gap and pioneer the field. In this context, this research aims to determine the evaluations of academics about an academic text generated with ChatGPT and to get their opinions about ChatGPT. In this direction, the following research questions were addressed.

- Our study was designed to answer the following research question in the quantitative phase: How do academics rate the academic text generated by ChatGPT?
- Our study was designed to answer the following research question in the qualitative phase: What are the opinions of academics who have used ChatGPT about the positive/negative aspects of ChatGPT and possible use in the future?

LITERATURE REVIEW

In the literature, it is seen that there are many studies on chatgpt and other chatbots. These studies have generally focused on the possible benefits and threats of their use in education. To our knowledge, our work is the first study that qualitatively analyzed academics' sentiments and feedback on ChatGPT's academic writing capabilities. We contribute to the literature by providing a snapshot of the early public responses to this latest technology.

In a study (Adiguzel et al., 2023)., possible uses of ChatGPT in the field of education were examined. According to the study, while modern chatbots like ChatGPT offer numerous benefits, their implementation in education raises significant ethical and practical concerns. The authors aim to offer valuable insights into how AI can be effectively integrated into education to aid both teachers and students, while also encouraging responsible and ethical use. In a similar study, Halaweh (2023) offered real-world examples of how ChatGPT may be used for academic writing. The author suggested a policy for universities and instructors about ChatGPT to match the specific demands of their institutions and courses.

Susnjak (2022) carried out a research using ChatGPT to evaluate its capacity for critical thinking as opposed to just knowledge retrieval. High levels of precision, coherence, and accuracy were shown in the results. Similar to this, Khalil and Er (2023) tested how well ChatGPT-produced writings might be identified by plagiarism detection software. Out of the 50 essays examined, 40 had a similarity score of 20% or less, suggesting a high degree of originality, according to their findings. Contrarily, Dowling and Lucey (2023)

noted that while ChatGPT has strengths in idea generation and data identification, it has problems in literature synthesis and the creation of useful testing frameworks in the field of finance research.

In another study, the researchers employed a three-stage instrumental case study approach, which involved analyzing tweets using social network analysis, conducting interviews and analyzing their content, and investigating the experiences of users, all to explore the concerns associated with using chatbots in education, particularly ChatGPT, among early adopters. The findings of the study indicated that while ChatGPT is a potent tool for educational purposes, it should be used with caution, and more guidelines on its safe use in education need to be established. Additionally, the study identified several research areas and questions that researchers and practitioners should explore for a safer and better adoption of chatbots, particularly ChatGPT (Tlili et al., 2023).

A meta-analysis study investigated the effectiveness of chatbot technology in achieving educational outcomes. The results indicated that chatbots had a medium-to-high overall effect size on educational outcomes, regardless of intervention duration, chatbot roles, and learning content. Chatbot technology had a positive impact on explicit reasoning, learning achievement, knowledge retention, and learning interest. However, chatbots did not significantly improve critical thinking, learning engagement, and motivation. These findings suggest that teachers and instructors can use appropriate teaching methods to facilitate sustainable education based on the benefits that chatbots offer (Deng & Yu, 2023).

Chocarro et al. (2023) investigated the teachers' usage intention of a chatbot in an educational setting, taking into account conversational design decisions and teachers' characteristics. The study found that teachers' perceived usefulness of the chatbot had a significant and positive impact on their intention to use the technology. It was observed that enhancing the performance and usefulness of chatbots is crucial in encouraging teachers to adopt this technology for their professional duties.

Sok and Heng (2023) examined the advantages and disadvantages of utilizing ChatGPT in the fields of education and research. They suggested that ChatGPT has five primary benefits, which include facilitating learning assessments, improving teaching techniques, providing virtual personal tutoring, generating an outline, and encouraging the development of ideas. Nonetheless, they indicated that there are also certain risks associated with using ChatGPT, such as academic dishonesty, unfair evaluation of learning, inaccurate data, and an excessive dependence on artificial intelligence.

Among the studies in the literature, the most similar study to our study was conducted by Donmez et al. (2023). They investigated the advantages and difficulties encountered when using the ChatGPT application in scientific research. They indicated that although artificial intelligence technologies offer advantages to researchers in terms of validation, innovation, and presenting various perspectives, there are issues with reliability when producing content and ethical concerns regarding plagiarism. They concluded that artificial intelligence does not write articles for researchers but rather provides suggestions and assistance during the article-writing process.

In a study on the use of ChatGPT at the university level, data were collected from 7 academics and 14 PhD students and the responses were analyzed using thematic content analysis. According to this study the themes emerged as "Evolution of learning and education systems", "changing role of educators", "impact on assessment and evaluation", "ethical and social considerations", "future of work and employability", "personalized learning", "digital literacy and AI integration", "AI as an extension of the human brain", and "importance of human characteristics".

THEORETICAL FRAMEWORK

This study is designed within the diffusion of innovations theory (DIT) and Uses and Gratifications theories (UGT). It can be said that these theories are generally used in studies on communication, media and the use of new technologies. In one study, McQuail and Windahl (1993) stated that, from a UGT perspective, researchers should seek answers to the questions "Why do people use media?" and "What do they use it for?" rather than "how does media affect people?" Within the UGT framework, it is also possible to explain why people use new technologies such as ChatGPT and for what purpose (Durak, 2017).

According to DIT by Rogers(1995), innovation can be an idea, an application, or an object that the individual or organization considers novel. Ultimately, innovation need not be an unknown concept or design because if the individual or organization has not yet utilized it, it can be considered innovative (Berger, 2005). Innovation can be defined theoretically as a new product, technology, perspective, or solution to a problem for individuals or organizations (Demir, 2006). Rogers (1995) noted that, according to the model, the innovation decision-making process consisted of five phases: knowledge, persuasion, decision, adoption, and confirmation. During the information phase, the individual receives details about innovation and its advantages. Next, in the convincing phase, the individual evaluates this innovation's negative and positive aspects and adjusts their attitude accordingly. In the decision phase, the individual accepts or rejects the innovation. If the individual accepts, the application phase will occur. In the approval phase, the individual confirms and strengthens the fitness-related decision (Orr, 2003). In this study, ChatGPT is regarded as an innovation for academics because they did not use it previously.

METHOD

This section covers the research model, data collection tools, study participants, data analysis, validity and reliability studies and the application stage of the study.

Research Model

In this study, the convergent parallel design, one of the mixed method designs, is utilized. This design combines qualitative and quantitative methods to produce triangulated results. Two data sets are initially collected simultaneously and then analyzed using quantitative and qualitative analytical techniques (Creswell & Plano Clark, 2018; Shorten & Smith, 2017). In a convergent design, combining quantitative and qualitative data will enable the researcher to comprehensively understand the one provided by quantitative or qualitative results alone. It is a method that combines two data sets to obtain a complete picture of the issue being investigated and to validate one set of findings with the other (Creswell & Plano Clark, 2018).

Data Collection Tools

In this study, we employed a mixed-methods approach, collecting both quantitative and qualitative data through an online form designed by the researchers. The form included questions aimed at gathering quantitative data, such as demographic information of the participants, their publication count, and the average number of manuscripts they review annually. Additionally, we incorporated a 5-point Likert scale for academics to quantitatively evaluate the academic text generated by ChatGPT. This scale was meticulously developed by analyzing manuscript evaluation criteria commonly used in major journals, covering aspects like originality, integrity, qualification, use of resources, problem identification, purpose, significance, adherence to academic writing standards, and language/expression. Qualitative data were also gathered through the form, focusing on participants' detailed opinions and evaluations about ChatGPT. This part of the data collection aimed to provide a deeper understanding of their perspectives and insights, which goes beyond the quantifiable aspects. The development of the interview questions was informed by the theories underpinning our study, ensuring that both qualitative and quantitative data were aligned with our research objectives. To enhance the tool's validity and reliability, educational technology experts specializing in measurement and evaluation reviewed the form. Their feedback was instrumental in refining and finalizing the tool, ensuring it effectively captured both quantitative and qualitative dimensions of the participants' responses.

Participants

Within the scope of the study, 45 academics from different universities were reached with convenience sampling methodology, and the data collection tool was applied. Since this study focuses on the use, advantages, and disadvantages of chatbots in academic publishing, the participant group was determined as academics by nature. The participants were categorized according to the fields of expertise stated in Table 1.

Table 1. Participants and their field of expertise

Group	Field of Expertise	Number of Participants
1	Computer Education and Instructional Technologies (CEIT)	22
2	Distance Education (DE)	13
3	Other Departments (OD)	10

According to Table 1, nearly half of the participants are academics from the CEIT department, while a significant portion is from DE, and the rest are from OD. Participants are coded with fields of expertise like CEIT -1, DE-7, and OD-4.

Data Analysis

The data collection tool, prepared within the scope of theoretical foundations in the study, was delivered to participants via Google forms through the researchers' personal networks. Quantitative data were analyzed in spreadsheet software, and graphics were created to represent the data. In the interview form, the participants were given detailed information about the purpose and method of the research. The questions and responses to the questions were transferred into a spreadsheet table under the prepared coding draft.

The academics' responses to the questions were examined one by one by two researchers, and each researcher formed his own interview coding key. A field expert evaluated the consistency of the coding keys, and the reliability study of the coding key was carried out. After concluding that consistency was achieved, the themes were formed within the scope of the study's theoretical framework. In addition, direct quotations are frequently used to effectively reflect academics' general views.

Validity and Reliability

The participants were informed that their views would be used only for academic purposes and that their names would be confidential. With these precautions, it was thought that they could express their opinions freely. The coding keys generated by the researchers were compared regarding reliability and consistency. Intercoder reliability is a measure of the consistency or agreement between two or more coders who are independently coding the same qualitative data (O'Connor & Joffe, 2020). It is an important parameter in qualitative research as it helps to ensure the validity and reliability of the findings. Cohen's Kappa is a statistical measure of inter-rater agreement that takes into account the possibility of chance agreement (Rau & Shih, 2021). It ranges from -1 to 1, with 1 indicating perfect agreement. The Cohen Kappa value between the two coders was calculated as 0.92 indicating almost perfect agreement. Afterwards, themes were created according to the coding keys and theoretical framework. Besides, direct quotations were included to reflect the views of academics truthfully and straightforwardly. In addition, the responses of academics were stored in a safe place to allow other researchers to review them on demand.

Application Stage

In this study, a total of 45 academics from different universities were reached, and the ChatGPT software was briefly introduced to these academics with various sample prompts. Then they were asked to test the ChatGPT software themselves for a week. The following command was entered in ChatGPT: "Write the literature review part of the article Investigating Collaborative Flipped Learning in approximately 1000 words". ChatGPT generated a 400-word text on the subject after this command (Appendix 1). The reasons for choosing flipped learning as a topic are that it is a popular method that has been widely studied and that it is close to the participants' fields of study. The text generated by ChatGPT was added to the data collection tool, making no additions. ChatGPT can generate a different text each time even if the same prompt is used. Afterwards, the online data collection tool was applied, and the academics were asked to read this text and rate it in terms of various titles.

Limitations of the Study

Although the participation group of this study is sufficient for qualitative methods, the fact that a higher number of academics were not reached for the analysis of quantitative data can be considered as a limitation. This sample size may not be sufficient to generalize the findings to a broader academic community. The concentration of participants from certain fields may limit the diversity of perspectives and insights into the broader applicability of chatbots in various academic disciplines. The use of an online form for data collection, although practical, may limit the depth of responses. In-person interviews or focus groups could provide more nuanced insights. The text generated by ChatGPT, being limited to 400 words, may not have fully captured the complexity or depth of the topic, potentially influencing the academics' evaluations.

FINDINGS

Within the scope of the study's quantitative data, the figures representing demographic data, professional experiences, the number of published articles and the annual average number of manuscripts reviewed will be presented. In addition, the participants' evaluations regarding the sample text generated by ChatGPT will be interpreted. As for the qualitative part of the study, the academics' responses were analyzed and coded, and the themes were generated from the coded data. The qualitative findings obtained were interpreted according to both DIT and UGT and were grouped according to (1) general feelings about ChatGPT, (2) The benefits and negative aspects of using ChatGPT and (3) the use and spread of ChatGPT.

General Information about Academics

In Figure 3, there is a graph of the experiences of 45 academicians in terms of working years. According to the graph, more than half of academics have a professional experience of 11-20 years.

Figure 3. Professional Experience of the Academics

The data on the number of articles published by the participants and the annual average number of manuscripts reviewed by the participants are supplied in Figure 4.

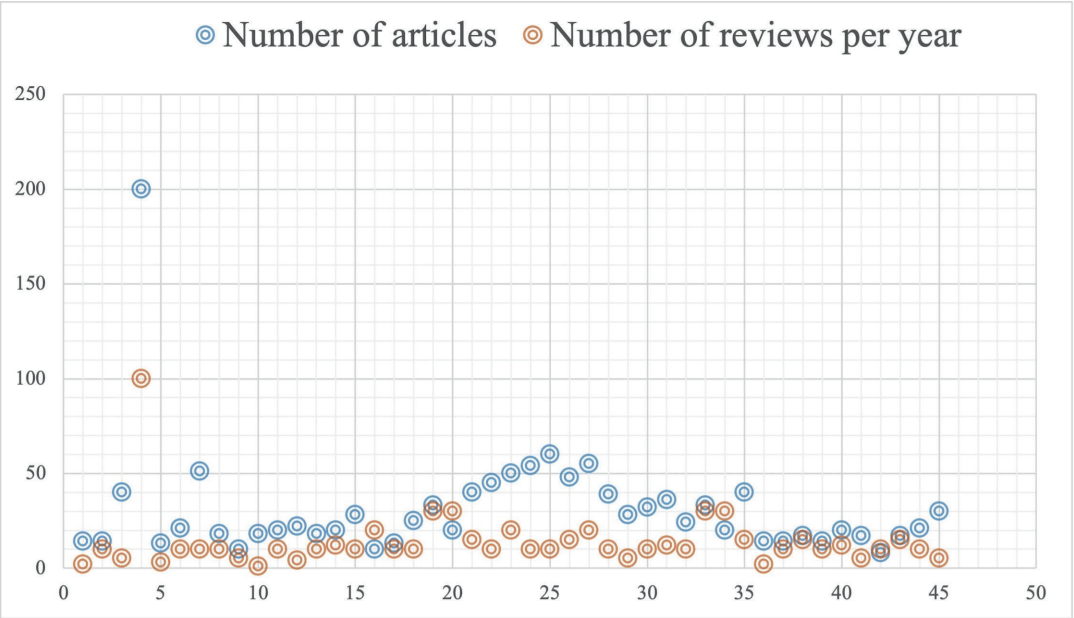

Figure 4. The Number of Articles and Annual Average Number of Manuscripts Reviewed by The Participants

According to Figure 4, it is found that the participants have an average of 10 to 60 articles (one academician with 200 articles is considered an exception), and the annual average number of manuscripts reviewed by the participants is between 1 and 30 (100 reviews are considered an exception). In general, it can be said that the number of articles published by the participants is in a good ratio according to their professional experience. Similarly, it can be thought that the annual average number of manuscripts reviewed by the participants is reasonable.

The participants were asked to rate the text produced by ChatGPT on a scale ranging from very poor to very good based on the various titles. Figure 5 displays the results of 45 participants' ratings of the text generated by ChatGPT.

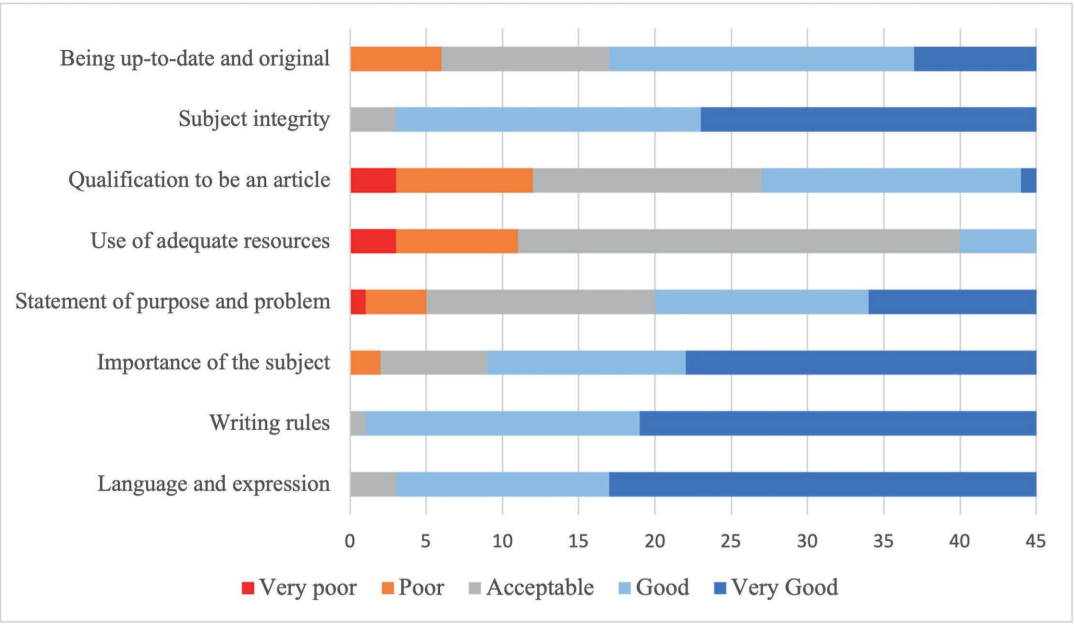

Figure 5. The Evaluation Form by the Participants of the Text Produced by ChatGPT

According to Figure 5, in the evaluation of the text created by ChatGPT, the titles that received the highest ratings (good + very good) from the participants were "Writing rules", "Language and expression", and "Subject integrity". These titles are followed by "the importance of the subject". "Use of adequate resources" and "qualification to be an article" are among the topics that receive low participant ratings. The titles "Being up-to-date and original" and "statement of purpose and problem" received different ratings from the participants.

General Feelings about ChatGPT

The participants were asked about their feelings about using ChatGPT. The findings were reduced into themes, and their frequencies are supplied in Table 2.

Table 2. General Feelings About Using ChatGPT

Theme	Frequency (f)
General feeling	
Astonishment	19
Pessimism	13
Anxiety	9
Hopefulness	7

It was found that most participants stated that they felt astonished after the ChatGPT experience. This feeling is followed by Pessimism, Anxiety and Hopefulness. About the "astonishment" theme, CEIT -7 expressed her thoughts as follows: "*I was quite amazed. This is a decent introduction. A few graduate students can compose a text like this.*" As for the Pessimism theme, DE-2 stated, "*It is obviously a terrible situation that people can write articles without any effort,*" whereas CEIT -3 stated, "*There is no reason why a graduate student who speaks a foreign language cannot write homework and article proposals with ChatGPT. They can graduate easily...*" While it was observed that some participants were hopeful about the development of such software, one participant, OD-1, said, "*This version has been very successful, and I am very hopeful about future versions.*"

The Benefits and Negatice Aspects of Using ChatGPT

The findings and frequencies regarding the participants' opinions about the benefits and negative aspects of using ChatGPT are presented in Table 3.

Table 3. The Benefits and Negative Aspects of Using ChatGPT

Theme	**Frequency (f)**
Benefits	
Time & energy saving	29
Contribution to academic writing	19
Facilitating role	15
An innovative software	13
Increase in the number of publications	9
Negative aspects	
Individual effects	
Negative effects on reading habits	24
Reduces originality	19
Negative effects on creativity	14
Laziness	10
Academic effects	
Academic dishonesty	21
May cause monotonous writing	18
Fake publications will increase	16
May terminate some sectors	12

The themes of benefits and negative aspects emerged from the answers given by the participants. The theme of negative aspects is also divided into individual and academic effects. The most prominent title under the theme of the benefits is "time & energy saving", followed by "contribution to academic writing" and "facilitating role". Regarding the "time & energy saving" theme, which most participants emphasized, CEIT -5 stated that "*I think this software will save time in terms of the introduction and literature review sections, on which a lot of time and effort is spent*", while OD-2 commented: "*It will make things easier and significantly reduce the effort spent in the introduction sections, which are difficult places to write*". DE-5 stated, "*I think it will facilitate the academic writing processes and make the processes more efficient*" on the theme of "contribution to academic writing", and OD-7 stated, "*I think it can make it much easier to write introduction part in articles*". Regarding the facilitating role theme, CEIT-16 said, "*it can be used to help academics, especially in literature review*", while CEIT-21 said, "*Content can be created for the introduction section. The software can make serious contributions to the literature review*".

The responses given under the theme of negative aspects were evaluated as individual and academic effects. As for the theme of "individual effects", the factors of "negative effects on reading habits" and "reduces originality" come into prominence. These views are followed by "negative effects on creativity" and "Laziness". Regarding the theme of reading habits, CEIT-10 stated that *"It may have a negative impact on individuals' reading habits and their ability to investigate the subject"*, while OD-2 concurred and stated, *"It may diminish research and reading skills."*. Regarding the theme of "reduces originality", many participants stated that the ChatGPT-generated texts would decrease the originality in publications. CEIT -9 and OD-1 defended the same view and commented: *"Eventually, there will be problems with the authenticity of the studies..."*. Almost all 10 participants who put forward their view regarding the theme of laziness expressed with similar expressions that such software can cause laziness after a certain period.

The "Academic effects" theme under the "negative aspects" theme includes the academic evaluation of negative situations related to ChatGPT. Among the answers given by the participants, the most prominent are "academic dishonesty" and "may cause monotonous writing". These themes are followed by "fake publications will increase" and "may terminate some sectors". CEIT -6, one of the many participants who expressed their opinions on the theme of academic dishonesty, made the following comment: "*This software can handle most of the article writing. The author can submit the article to journals after a proofreading process. This will lead to ethical violations*". A participant of DE-4 stated his the title "may cause to monotonous writing" as *"… it may cause to monotonous writing because the articles will come out of the same environment*". As for the theme of "fake publications", which many participants demonstrated, DE-7 expressed his concern "*I am afraid that fabricated articles will be written using fake data with this software*". Among the answers given, one of the most negative ones is under the "may terminate some sectors" theme. CEIT-13, one of the participants who advocated this view, said, "*ChatGPT may cause the existence of the academic profession to disappear*." Another participant, OD-5 expressed his opinion that "*if the writing style is differentiated by ChatGPT, then academic activities such as academic writing, publishing articles and presenting papers may come to an end*".

Use of Spread of ChatGPT

The findings and frequencies regarding the participants' experience and views of ChatGPT and their opinions about making ChatGPT widespread can be seen in Table 4.

Table 4. Findings Regarding the Use and Spread of ChatGPT

Theme	Frequency (f)
Satisfaction with ChatGPT	
Positive	
ChatGPT can be used as a guide for academic writing.	18
The text is well organized	11
ChatGPT explained the subject very well	7
Negative	
The sample text is insufficient to be an academic article	7
Neutral	
ChatGPT can be used for simple tasks like homework etc.	9
Making ChatGPT widespread	
Positive	
ChatGPT can be used as supplementary	24
The text generated by ChatGPT can be used as a draft	15
Neutral	
ChatGPT can be used in non-academic studies	16
ChatGPT can be used after checking for plagiarism	9
Negative	
ChatGPT should never be used in academic publications	9
There will be a problem of originality in publications	8

The participants were asked their opinions about their satisfaction with ChatGPT and making ChatGPT widespread. The themes under satisfaction with ChatGPT are classified as positive, neutral and negative. Regarding the theme of positive satisfaction, "ChatGPT can be used as a guide" has become prominent among responses. This view is followed by "the text is well organized" and "ChatGPT explained the subject very well" themes. CEIT -8 expressed his thoughts: "*I intend to use ChatGPT in the future. An assistant, who can scan the literature faster and more accurately than I can, will make my work easier as it is a guide*". OD-4, one of the many participants who expressed a positive opinion about the "the text is well organized" theme, said, "*I was really surprised when I examined the sample text. The transition between paragraphs is very good. It has prepared a very fluent text*". DE-7 said, "*I will use ChatGPT. It is very successful, especially in organization and giving ideas*". Although most participants had positive opinions about ChatGPT, there were also some negative views. Participants who think this way generally stated that the sample text is insufficient to be an academic article. CEIT-11 said that "*ChatGPT has created a type of text that can be considered successful, but not every text created can be an academic publication. The limited use of resources and the reliability issues make me think seriously*". Another participant stated that he was partially satisfied with the text created by ChatGPT and commented that "*it can be used in simple homework, although not in academic studies.*"

Finally, the theme of "making ChatGPT widespread" is classified as positive, neutral and negative. The themes "can be used as supplementary" and "can be used as a draft" emerged under the positive theme. Within the scope of positive opinions, CEIT-17 commented that "*ChatGPT can be used as a software to help researchers*", while DE-6 stated that "*each researcher can have an AI assistant that he/she trains according to his/her own rules*". Under the theme "The text generated by ChatGPT can be used as a draft", CEIT-14 commented that "*text produced by ChatGPT can be considered as a draft*". Under the negative theme, some participants stated that ChatGPT should not be used in academic studies. Some participants emphasized that there may be problems with the originality of the publications. DE-7 stated that "*this kind of software should never be used in academic publications. The resulting text has no credibility. It is unclear where it was taken from. It will also bring ethical problems."* As for the originality concern in publications, CEIT-19 stated that "*after a certain period of time, the same type of publications may be encountered. However, the human factor is very important, writing styles are important… Without these, academic publications will consist of repetitive articles."*

CONCLUSION, DISCUSSIONS AND SUGGESTIONS

When the evaluations of the academics about the academic text generated with ChatGPT are examined, quite surprising results are obtained. It has been observed that the sample text received very successful evaluations from academics in the title of "writing rules" and "language and expression". Qualitative data also support this result. Most academics have argued that the text generated by ChatGPT is quite successful. On the other hand, academics considered that the references in the sample text were not up-to-date and that not enough references were used as a deficiency. Some academics' opinions that the generated text cannot be an academic publication on its own support this situation.

Due to the open-ended questions, it was revealed that the academics tried such a software for the first time, and it was seen that they mostly felt "astonishment". It can be expected that people will be surprised when they see what artificial intelligence can do. Still, the emergence of emotions such as pessimism and anxiety besides astonishment needs to be considered. Some academics stated that they had hesitations about ChatGPT and criticized the use of ChatGPT in academic publications.

Among the positive opinions that emerged under the theme of The Benefits and Negative Aspects of Using ChatGPT, it was stated that the theme of "time & energy saving" was expressed by most academics and that many stated that ChatGPT could be used as a facilitator and a contributor in academic writing. Speed and time saving were expressed as a core benefit of ChatGPT in literature (Eke, 2023; Fido & Wallace, 2023; Rathore, 2023). In line with these views, this software is seen by academics as a qualified and successful software in academic writing. Considering that with ChatGPT, meaningful texts can be created in a very short time on any academic topic; plus, it can be thought that such views of academics are as expected. Considering the opinions of academics about ChatGPT within the framework of uses and gratifications theory, it is seen that satisfactions such as "time & energy saving with ChatGPT", "facilitating role of ChatGPT", "ChatGPT can be used as a supplementary tool", among the positive opinions that have emerged, are also included in various studies in the literature (Dunne et al., 2010; Durak, 2017; Lim & Ting, 2012; Tinmaz, 2011; Wang et al., 2018; Wodzicki et al., 2012). Similarly, Donmez et al. (2023) stated that the texts produced by chatbots cannot be used directly in article writing, and that it is more appropriate to use such software as a support.

There have been negative opinions about ChatGPT, such as that it may negatively affect reading habits, reduce the originality of publications, and negatively impact the creativity of academics. It is normal that some people have negative thoughts towards technological innovations. Some academics have expressed the view that ChatGPT can cause academics to be lazy. The fact that ChatGPT significantly facilitates academic writing for academics may lead to this result. Other themes that emerged about the negative effects of ChatGPT are "academic dishonesty", "may cause monotonous writing", "fake publications will increase", and "may terminate some sectors". Similarly, there are some studies that raise ethical concerns about the use of ChatGPT in education as misinformation generation, bias and privacy, responsible implementation and leadership to ensure the ethical use of AI in education, and serious consequences of using ChatGPT in education and science (Baidoo-anu & Ansah, 2023; Firat, 2023; Willems, 2023). One of the themes that should be emphasized here is "may terminate some sectors". The emergence of technological innovations brings concerns about the future of many sectors. It is one of the assumptions spoken today that the developments in robotics and artificial intelligence fields will change professions such as medicine, the military, etc., in the future.

Finally, when the academics were asked whether they would use ChatGPT in the future, it was revealed that most thought of doing so. Sharing texts generated with ChatGPT by some academics on social media platforms supports this result. The theory of diffusion of innovations can explain this situation. Within the framework of this theory, the fact that academics have no previous ChatGPT experience means this application is an innovation for them. From the findings, despite serious concerns, most academics thought that ChatGPT would be useful in the academic field and stated positive opinions about it, showing they adopted this innovation. Considering that the academics thought the spread of ChatGPT, new versions of ChatGPT would benefit the academic community can be explained by a diffusion of innovations.

According to the results of this research and considering the advantages /disadvantages of using ChatGPT, these recommendations were made:

- Instead of a short text generated with ChatGPT, like in this study, a more comprehensive text, including other article sections, can be generated with ChatGPT, and qualitative and quantitative studies can be carried out on that text.
- Interdisciplinary research projects can be encouraged where experts from fields like computer science, linguistics, education, and psychology collaborate to explore the implications of ChatGPT and similar technologies in academic writing and research.
- It would be beneficial to conduct longitudinal studies to observe how the use of ChatGPT and similar AI tools evolve over time in academic settings. This would provide insights into the long-term impacts of these tools on academic writing, originality, and creativity.
- There is a need to develop comprehensive ethical guidelines and policies for using AI tools in academic writing. These should address concerns about academic dishonesty, originality, and the potential for AI to create monotonous or generic content.
- Integrating ChatGPT into academic curricula as a supplementary tool, teaching students how to effectively and ethically use such AI technologies in research and writing can be considered.
- AI literacy programs can be implemented for academics and students to enhance their understanding of AI capabilities, limitations, and ethical implications. This would help in informed and responsible use of AI tools in academia.
- Comparative studies can be performed to assess the performance of ChatGPT against other AI writing tools in academic settings. This can provide a clearer understanding of the strengths and weaknesses of various AI technologies in academic applications.
- The impact of AI tools like ChatGPT can be assessed on different academic professions, particularly in terms of job roles, responsibilities, and the evolving nature of academic research and publication.
- The effectiveness of ChatGPT and similar tools can be explored in different cultural and linguistic contexts. This is vital for understanding how AI tools perform in diverse academic environments.
- Public perception and acceptance of AI tools in academic publishing can be investigated. Understanding societal attitudes towards AI in academia can guide more responsible and community-accepted applications.

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APPENDIX 1

The Text Generated by Chatgpt

The flipped classroom model has gained popularity in recent years as a way to improve student learning and engagement. This approach involves flipping the traditional model of instruction, where students receive lectures in the classroom and complete assignments at home, by having students watch lectures and complete assignments in class, while using class time for interactive activities and discussions.

One variation of the flipped classroom model is collaborative flipped learning, where students work together in small groups to complete assignments and discuss course material. This approach has been shown to promote active learning and critical thinking, as well as improve social and communication skills.

Studies have found that collaborative flipped learning can lead to increased student achievement and engagement, as well as improved attitudes towards the course and the subject matter. For example, a study by Kim and Park (2013) found that students in a collaborative flipped learning environment had higher test scores and were more engaged in class compared to students in a traditional classroom. Similarly, a study by Huang and Chiu (2014) found that students in a collaborative flipped learning environment had better problem-solving skills and were more confident in their ability to apply what they had learned.

However, not all research on collaborative flipped learning has found positive results. A study by Lee and Lee (2015) found that students in a collaborative flipped learning environment had lower test scores and were less engaged in class compared to students in a traditional classroom. The authors attributed this to the lack of structure and support in the collaborative flipped learning environment, which may have led to confusion and frustration among students.

Despite these mixed findings, collaborative flipped learning has the potential to be an effective approach for improving student learning and engagement. Further research is needed to understand the factors that contribute to its success, as well as to develop strategies for addressing the challenges that may arise in a collaborative flipped learning environment.

Overall, the literature on collaborative flipped learning suggests that this approach has the potential to improve student achievement and engagement, but more research is needed to understand the conditions under which it is most effective. Further investigation into the use of collaborative flipped learning in different subject areas and contexts is necessary to fully understand its potential as a teaching and learning strat

THE EFFECT OF STEAM APPROACH DIGITAL TEACHING MATERIALS ON INCREASING CREATIVE PROBLEM-SOLVING SKILLS

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ABSTRACT

This study aims to determine the effect of using STEAM digital teaching materials on increasing creative problem-solving skills. This study has a quasi-experimental research design with a nonequivalent control group. This study employed a random sampling technique and obtained Class 8-F as the experimental class and Class 8-H as the control class. Data were collected using documentation, tests, and questionnaires. The data analysis carried out was a homogeneity test, normality test, t-test, n-gain test, and analysis of students' responses. According to this study, it can be concluded that there is an effect of STEAM digital teaching materials to increase creative problem-solving skills. The t-test results indicate a significant difference in students' average creative problem-solving skills in the experimental and control classes. The effect of STEAM digital teaching materials is proven by an increase in creative problem-solving skills, which are analyzed using N-gain, resulting in the high category (0.73) for the experimental class with STEAM digital teaching materials and the medium category (0.50) for the control class after using STEAM digital teaching materials.

Keywords: STEAM, Digital teaching materials, Creative problem-solving skills.

INTRODUCTION

Science and technology in the 21st century are developing rapidly, so many countries are improving the quality of various sectors, including education. The development of science and technology requires students to be innovative and have the skills to survive and thrive in an increasingly complex life (Zubaidah, 2019). These skills that students must have are known as 21st-century skills. 21st-century skills include problem-solving, critical thinking, communication, collaboration, and creativity (Zubaidah, 2016). The 21st century requires students to have problem-solving, creative thinking, and communication skills. In the current era of globalization, students need creativity in solving problems because it can help students create a framework of thinking that is neatly arranged in solving complex problems.

Creative problem-solving skills emphasize reaching an alternative idea in the problem-solving process (Isrok'atun, 2012). Phaksunchai et al. (2014) concluded that creative problem-solving skills help students deal with and solve problems using new methods that are more effective and appropriate for each situation. Isrok'atun (2012) suggests that creative problem-solving consists of several indicators: (1) objective-finding, (2) fact-finding, (3) problem-finding, (4) idea-finding, (5) solution-finding, and (6) acceptance-finding. Creative problem-solving uses more profound thinking than the average level of thinking and focuses on finding unique ideas.

The results of preliminary observations and interviews with science teachers at SMP Negeri 1 Purwodadi show that students' creative problem-solving indicators are still low. When the teacher presents a problem, most students cannot provide the right solution. This situation shows students' inability to think divergently and convergently. Data on the final odd semester assessment show that only 25-35% of students score above the passing grade. The learning resources at SMP Negeri 1 Purwodadi are textbooks and teaching materials by the teacher. They have dense content and lack supporting figures to attract students' interest and motivation in learning. Applying appropriate learning resources and models will make learning more effective and flexible, so it is hoped that it can improve students' creative problem-solving skills.

Teaching material is a subject matter arranged systematically for teachers to use and for students to achieve learning objectives. Teaching materials must be arranged interestingly and systematically, including learning material, methods, and evaluation (Gomez-Pablos et al., 2017). Isrok'atun (2012) concluded that teaching materials can improve creative problem-solving skills by understanding the material and exploring problem-solving skills more creatively.

STEAM can be interpreted as "education to improve students" through interest in and understanding scientific technology to foster STEAM literacy. STEAM education combines the arts in STEM to increase student engagement, problem-solving skills, creativity, and innovation (Colucci-Gray et al., 2017; Thuneberg et al., 2018). Miller et al. (2019) concluded that learning with a STEAM approach makes students more appreciative of combining science and art with various forms of creativity, critical thinking, and imagination skills when students try to understand various existing problems.

Several studies regarding STEAM's influence on creativity and problem-solving skills have been conducted separately (Perignat & Katz-Buonincontro, 2019; Erol et al., 2023; Quigley et al., 2017). According to Irwandani et al. (2017), teaching materials make students learn independently and make it easier to understand the material. One of the ways to use teaching materials to improve creative problem-solving skills is through learning with a STEAM approach so that students better understand material from various scientific disciplines. Integrating several scientific disciplines helps students better analyze, collect information, and solve problems that are interconnected with other problems. The integration of all aspects of STEAM can make the learning process more meaningful (Asmuniv, 2015).

Lee et al. (2017) researched creative problem-solving skills as steps in activities in the STEAM learning approach, but there has been no research on the influence of STEAM digital teaching materials on creative problem-solving skills in science learning. This study used digital teaching materials with a STEAM approach on light and optical devices for eighth-grade junior high schools. STEAM digital teaching materials are innovations in presenting material in an electronic format containing five STEAM elements: science, technology, engineering, art, and mathematics. STEAM is a development of STEM by adding elements of art so that in the learning process, it can develop students' creativity by creating a fun learning tool. Digital teaching materials with a STEAM approach will help students better understand the material studied by linking it to various disciplines. Digital teaching materials will later be uploaded to Google Classroom. Using Google Classroom can make it easier for teachers to manage learning and accurately deliver information to students (Hardiyana, 2015). Iftakhar (2016) states that Google Classroom has several advantages. It saves time, is easy to use, flexible, cloud-based, and free.

Based on these problems regarding students' low creative problem-solving, STEAM digital teaching material is necessary for research. This study aims to determine the effect of using STEAM digital teaching materials on increasing creative problem-solving skills.

METHOD

Research Design

This study has a quasi-experimental research design with a nonequivalent control group. The research design is presented in Figure 1.

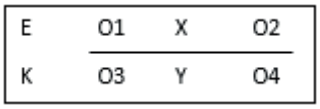

Figure 1. Research Design (Sugiyono, 2018)

Information:

X: Treatment using STEAM digital teaching materials

Y: Treatment using science books from school

O1: Experimental class before treatment

O2: Experimental class after treatment with STEAM digital teaching materials

O3: Control class before treatment

O4: Control class after treatment with science books from school

Participants

This study employed a random sampling technique. The homogeneity test obtained the classes as the research samples: Class 8-F as the experimental class and Class 8-H as the control class.

Data Collection and Analysis

Data were collected using documentation, tests, and questionnaires. The questionnaire method is used to find out students' responses to using STEAM digital teaching materials. The test method is to determine students' creative problem-solving skills. The data analysis carried out was a homogeneity test, normality test, t-test, n-gain test, and analysis of students' responses. The results of the t_{count} of the t-test were compared to t_{table} with a significance level of 5%. H_0 rejection criteria is if $t_{count} \geq t_{table}$ (Sugiyono, 2018). Meanwhile, for the N-gain analysis, the categories are listed in Table 1.

Table 1. Category of N-gain (Hake, 1999)

Range	Category
$g < 0,3$	Low
$0,3 \leq g < 0,7$	Medium
$g \geq 0,7$	High

FINDINGS

This study aims to measure the differences in use caused by applying STEAM digital teaching materials to increase creative problem-solving skills. STEAM digital teaching materials have an effect if there are differences in the experimental class's creative problem-solving skills, which are better than the control class.

The difference was tested using STEAM digital teaching materials on light and optical devices to increase creative problem-solving skills, using the average difference test in the control and experimental classes. The calculation results are presented in Table 1

Table 2. The Difference of Mean Score Test between Experimental and Control Classes

Group	N	Dk	t_{table}	t_{count}	Criteria
Experiment Control	32	62	1,999	8,047	H_0 is rejected

Table 2 shows that $t_{count} > t_{table}$ so that H_1 is accepted; that is, there is a significant difference in the average increase in creative problem-solving skills in the control and experimental classes. This difference is inseparable from appropriate learning models and resources when teaching and learning activities occur. In line, Widayoko et al. (2018) argued that the results of the t-test showed that learning in the control and experimental classes had significant differences in improvement, so the use of learning models and resources can affect the improvement of students' learning outcomes. The difference in the increase in creative problem-solving skills is affected by teaching materials in learning. The results of the n-gain test are analyzed to determine which teaching materials can increase creative problem-solving skills.

The increase in creative problem-solving skills from the beginning to the end of the meeting was analyzed using N-gain. The increase in creative problem-solving skills is presented in Table 3.

Table 3. The Increase of Creative Problem-Solving Skills

Data	Experiment		Control	
	Pretest	Posttest	Pretest	Posttest
Average	47,65	85,31	41,64	70,70
N-Gain	0,73 (High)		0,50 (Moderate)	

Table 3 shows that the experimental class's creative problem-solving skills are higher than the control class. The N-gain of the experimental class is 0.73 in the high category, while the control class is 0.50 in the medium category (Hake, 1999).

The N-gain results show that the experimental class that uses STEAM digital teaching materials has a higher increase in creative problem-solving skills than the control class that uses science textbooks. This result is under Ko & Hong (2018), who state that learning by applying the STEAM approach has a positive effect on significantly increasing students' creative problem-solving skills.

The analysis results of the increase in the average of each creative problem-solving skill indicator in the experimental and control classes were obtained from the test with ten questions of six indicators of creative problem-solving skills. The complete analysis results are displayed in Figure 2.

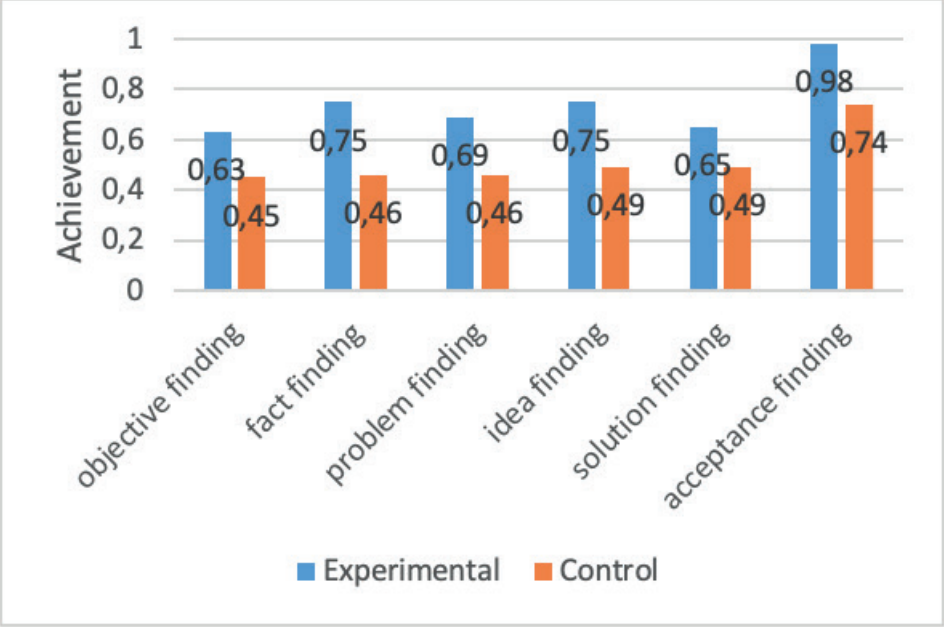

Figure 2. Average Increase of Each Creative Problem-Solving Skill Indicator

Figure 2 shows that the average increase for each creative problem-solving skill indicator in the experimental class is better than that of the control class. The highest average increase for each indicator was found in the sixth indicator, the acceptance finding. The results were 0.98 and 0.74, with the experimental class being better than the control class. The indicator with the lowest average increase, the objective finding, showed that the experimental and control classes were almost equal, but the control class was slightly better than the experimental class. The increase in the control class was 0.63, while the experimental class was 0.45.

DISCUSSIONS AND CONCLUSION

Creative problem-solving skills combine creativity or an idea with elements of novelty and uniqueness from the person who created it and a problem or a situation that presents a problem to solve (Isrok'atun & Tiurlina, 2014). Therefore, creative problem-solving is solving a problem through creative or renewable ideas. According to Isrok'atun (2012), creative problem-solving skills emphasize reaching an alternative idea in a problem-solving process. Creative problem-solving is used to identify problems and plan a solution.

The learning model also affects the increase in students' creative problem-solving skills. STEAM is one of the learning tools that can help students develop creative problem-solving skills. STEAM learning is contextual learning that invites students to understand the phenomena around them better so that students can better explore their abilities (Yakman & Lee, 2012). Through STEAM learning, students can also build their understanding and knowledge through creating a project (Mu'minah, 2020). STEAM education aims to teach students to apply the main content and practice each STEAM discipline in all situations students face (Bybee, 2013).

The learning process in this study used the PjBL learning model with the STEAM approach. The PjBL-STEAM model positively impacts students, especially developing soft skills (Anindya & Wusqo, 2020). The learning process has several stages, starting with essential questions. Students were given a problem related to light and optical devices through STEAM digital teaching materials and videos through PowerPoint. This stage trains students' creative problem-solving skills on indicators of objective-finding, fact-finding, and problem-finding in digital teaching materials in the science exploration sub-chapter and videos displayed via PowerPoint. Objective-finding indicators were created when the teacher presented a problem and students re-described it using their language. After this, students were invited to understand the goals for solving problems from the studied material.

Starting with the essential question stage also trains students in fact-finding indicators when they observe problems in the video in the Observing sub-chapter or things in their surroundings related to light and optical devices. After that, students determined the facts of the matter. Other results from this observation can train students in problem-finding indicators, where students formulate essential questions based on their observed problems. Students used these questions to determine the problems to be solved through a project. This statement is reinforced by Cunningham's opinion in Sengul and Katranci (2015), which states that students must thoroughly understand the subject/situation in problem-finding activities.

In the design project stage, students made a project design and collected various information needed to make the project in the Understanding sub-chapter, complying with the instructions from the teacher. At this stage, it can be seen how active students are in finding and gathering information from various relevant learning sources. This stage also trains students' idea-finding indicators, where students' activeness is apparent when students start exploring ideas or ideas to solve problems, and then students have to re-analyze the ideas they have designed. Solving some problems can be done by formulating new ideas and strategies that are more innovative (Nuzliah, 2015).

Creating the schedule stage emphasizes the engineering field in the project creation, as contained in the Counting sub-chapter on STEAM digital teaching materials. Students made a schedule for doing a project by preparing the tools and materials needed following the design that had been made. At this stage, students practiced the solution-finding indicators. Students thought of the best solutions from their creative ideas, as in the Creative sub-chapter in the previous idea-finding stage.

The next stage is monitoring the students and the project's progress. Students asked questions about project assignments they had not understood, presented project developments, and explained the relationship

between light and optical devices in the project. At this stage, students were trained in idea-finding and acceptance-finding. Students presented the project's progress and analyzed the relationship between light and optical devices. This statement is reinforced by Polya's opinion in Phonapichat et al. (2014), who reveals that one of the creative mathematical problem-solving processes is to develop a settlement plan. This stage trains acceptance-finding indicators where students describe the steps for answers based on the determined concepts/formulas.

The last stage is assessing the outcomes and evaluating the experience. Students and the teacher evaluated the project's results by linking the STEAM elements and expressing their experiences when working on the project. At this stage, students practiced the acceptance-finding indicator. Experimental class students better understand the relationship between STEAM in learning and projects because the examples and applications are listed and explained in STEAM digital teaching materials. Control class students still do not understand the relationship between STEAM material and approaches to learning and projects.

Rahmazatullaili et al. (2017) stated that project-based learning allows students to solve problems through creative thinking and interactions that lead to actual problem-solving. This study uses the PjBL learning model with the STEAM approach, which is applied to both classes by applying different learning resources and PhET simulations to support the learning process so that creative problem-solving skills in both classes increase equally. PhET simulation was carried out on reflection and refraction of light because students can directly conduct experiments to find concepts. In line with Riantoni et al. (2019), using PhET simulations in learning can help students learn new topics, build concepts or skills, and strengthen ideas. However, the increase in creative problem-solving skills in the experimental class using STEAM digital teaching materials is higher than in the control class using science textbooks. This STEAM learning can be applied through teaching materials designed based on STEAM characteristics so that students develop creative problem-solving skills. The teacher's task here is to act as a motivator and facilitator. Teaching materials allow students to formulate problems, provide arguments, and evaluate problems (Rosida et al., 2017).

The current condition of distance learning requires digital learning media that can be used independently, such as digital teaching materials (Sunarti & Rusilowati, 2020). Digital teaching materials can help students understand material during distance learning activities. Teaching materials with pictures and videos also make students more active and not easily bored when learning. Lawe et al. (2021) argued that digital teaching materials do not bore students in the learning process because they contain elements of text, images, and videos that are more interesting to students. The results of this study are also supported by Manurung (2020), who states that using digital teaching materials provided by teachers can increase students' attention and transfer knowledge and understanding of the material well so that students' learning outcomes increase.

STEAM digital teaching materials also contain text, images, and video to facilitate distance learning. In line with Minarni et al. (2019), using visual media by combining images and text can be more fun, engaging, and meaningful, increasing students' curiosity about what will be learned. Visual media with pictures and colors can facilitate students' understanding, strengthen memory, and foster interest in learning. STEAM digital teaching materials can enhance students' creative problem-solving skills because they contain STEAM aspects, which can train creative problem-solving skills at each stage of learning. STEAM digital teaching materials contain a summary of material that can help students learn more efficiently and contain pictures and videos that can help broaden students' horizons. The summary of the material in the teaching materials is arranged in several STEAM aspect sub-chapters. The increase in creative problem-solving skills is divided into six indicators, which are analyzed as the highest and lowest increases.

The acceptance-finding indicator has the highest average increase compared to other indicators, with 0.98 in the experimental class. The increase in this indicator occurred due to the effect of the treatment from STEAM digital teaching materials, which increased students' creative thinking skills. Without STEAM digital teaching materials, the results of an increase in the control class using the science books from school were only 0.74. Acceptance-finding is the stage where possible sources of assistance are considered, potential implementation steps are identified, the most promising solutions are focused and prepared for action, and specific plans are formulated to implement solutions (Isrok'atun et al., 2018). STEAM digital teaching materials affect the increase in acceptance-finding through the Counting sub-chapter, which contains the application of formulas in learning materials. This sub-chapter contains mathematics aspects.

Students also filled in mini-proposals already available on STEAM digital teaching materials to be presented at the last meeting by linking them to light and optical devices and the STEAM approach in the project. In addition to presenting the project's results, students shared their experiences working on it. The objective-finding indicator obtained the lowest average increase among other indicators, with 0.63 in the experimental class. In the objective-finding stage, students identify and explain general descriptions of the phenomena described and shown (Nuraziza & Suwarma, 2018). Students were then invited to understand the goals for solving problems from the study material.

The low objective finding in the experimental class is because the digital teaching materials do not yet fully contain the goals and objectives of each meeting. Therefore, students find it difficult to relate the goals of the problem-solving process to the problems given, so the average increase obtained is lower than that of other indicators. The increase in the average objective finding in the control class was 0.45 because students did not understand the events presented by the teacher, so they could not correctly determine the purpose of solving the problem.

The role of STEAM digital teaching materials that still need to be improved is achieving the objective-finding indicator. Rahman (2011) argued that students' low learning outcomes can occur due to the lack of optimal learning media and resources due to disturbances in their application, such as misinterpretation and lack of attention. Students pay less attention because of the monotonous material delivery or focus more on other things outside of learning. Disturbances of misinterpretation occur due to the formation of an inaccurate perception of an object, a symptom, or an event (Rahman, 2011).

The results of this study are also supported by Isrok'atun (2012), who states that teaching materials are very effective in assisting the learning process to improve students' creative problem-solving skills, as evidenced by the increased pretest and posttest results. In line with McCrum (2017), using teaching materials effectively increases creative problem-solving skills through problem-based interdisciplinary. This study utilizes teaching materials in the technology field, and students can access teaching materials with computers or smartphones. This teaching material applies the STEAM approach, making the learning process more meaningful and allowing students to integrate learning in various disciplines (Asmuniv, 2015).

Students' responses to STEAM digital teaching materials is 80.63% in the good category, which exhibits the effect of using teaching materials in the difference in the average assessment results in the experimental and control classes. Students' positive responses follow Fidiantara et al. (2020), who stated that teaching materials can encourage students' interest and motivation in teaching and learning classroom activities. Herawati and Muhtadi (2018) also argued that electronic teaching materials can increase students' attention to materials and make learning more persuasive. Learning involving students' direct participation will be more effective and efficient because they will find real experiences independently and explore their abilities, making learning more enjoyable. Fun learning will increase the motivation of students to take part in learning.

Most students stated that learning with STEAM digital teaching materials made them more active and happier in participating in learning activities because learning became fun, and they understood the material more easily. Project-making activities in STEAM digital teaching materials can also foster creative problem-solving skills because students face problems that must be solved. STEAM digital teaching materials are uploaded to Google Classroom, which students can access at any time. This response shows that STEAM digital teaching materials are suitable for use in learning activities and can be an alternative that can be applied in schools.

According to this study, it can be concluded that there is an effect of STEAM digital teaching materials to increase creative problem-solving skills. The t-test results indicate a significant difference in students' average creative problem-solving skills in the experimental and control classes. The effect of STEAM digital teaching materials is proven by an increase in creative problem-solving skills, which are analyzed using N-gain, resulting in the high category (0.73) for the experimental class with STEAM digital teaching materials and the medium category (0.50) for the control class after using STEAM digital teaching materials.

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PROVIDING EDUCATIONAL ACCESSIBILITY FOR A PARALYZED STUDENT BY EYE-TRACKING TECHNOLOGY: A DESIGN-BASED RESEARCH STUDY

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ABSTRACT

This study explores the development of an eye-tracking solution for paralyzed students, enabling them to access and utilize personal computers for their education. It relies on eye-tracking technology, enabling computer control through eye movements. The study followed four phases: problem analysis, solution development, evaluation, and documentation. In the analysis phase, the problem for developing a solution was defined based on the interviews with the instructor, the paralyzed student, and his parents. The iterative and incremental development process was followed in the development phase with four development cycles. At the end of this phase, an eye-tracking-based computer control system and design principles were obtained to develop such a system. During the evaluation phase, paralyzed student used the system for two semesters. The final phase documented design principles for further eye-tracking systems to support paralyzed individuals' academic lives. By adhering to these design principles, there is a need to develop and adapt more solutions and systems for the benefit of paralyzed people, enabling them to access and maintain their academic lives. The study highlights the potential of eye-tracking technology for paralyzed students and promotes the development of similar solutions.

Keywords: Paralyzed students, educational technology, assistive technology, eye-tracking.

INTRODUCTION

Technological developments encourage researchers to investigate and leverage their advantages in the field of education. Regarding devices, especially mobile devices and multimedia resources, it is essential to utilize them while giving instruction or extracurricular activities (Farkhadov et al., 2017; Sung et al., 2016; Wang et al., 2019). Despite rapid technological enhancements, their usage is very limited for people with special needs. The use of technology for people with special needs is called assistive technology (AT). It is defined as the technology that is used to benefit from assistive technology devices, such as equipment, products, or systems that can be used to enhance the capabilities of disabled people and services that can provide direct assistance or help them use assistive technology devices (Assistive Technology Act of 1998, 1998; Assistive Technology Act of 2004, 2004). Using AT and information and communication technologies (ICT) has great potential for people with various disabilities (Bouck & Long, 2021; Ouherrou et al., 2019; Pasian et al., 2012). When applying ICT to people with disabilities, the essential point to be considered is matching the needs of the users with the potential technology and adapting it according to their differences in learning (Drigas & oannidou, 2013; Heiman et al., 2017; Mandula et al., 2016). Therefore, it is essential to include technology in education by providing adaptive learning environments for people with special needs (Skourlas et al., 2016). People with motor difficulties especially require adapting technology to access educational opportunities.

Despite the importance of technology usage in education, there is a lack of accessibility opportunities for paralyzed students (de Witte et al., 2018; Hersh & Mouroutsou, 2015; Morgado Camacho et al., 2017; Smith & Abrams, 2019). Participating in a class, whether physically or virtually, can be challenging for them. Technology, however, can serve as an invaluable tool, allowing them to attend classes with assistance (Nicolson et al., 2012). For instance, caregivers can facilitate their transport from home to school or university and provide support in note-taking, assignment writing, or reading materials. In the case of online courses, paralyzed students can stay at home, with caregivers helping them connect to the course and providing assistance throughout. While both scenarios for physical and online participation seem reasonable, there is a crucial need for dedicated caregivers to enable paralyzed students to fully engage in lessons. Unfortunately, many parents may face challenges in allocating continuous time to assist their paralyzed children. Another significant consideration in both scenarios is the assumption that students can communicate verbally with people around them and the world. If verbal communication is not possible, both scenarios fall short, making it impossible to fully integrate paralyzed students into the educational environment and provide equal opportunities for education.

At this point, eye-tracking technology emerges as a solution for providing computer input without physical interaction (Donmez, 2023; Donmez & Cagiltay, 2019). Amer, Kamh, Elshahed, and Ramadan (2021) developed an eye-controlled wheelchair using a webcam to capture eye movements. Similarly, Atasoy, Cavusoglu, and Atasoy (2016) developed an eye movement based system that controls a motorized electrical hospital bed using a webcam, while Uslu, Ari, Sumer, and Turker (2017) developed a wearable system for communication and control of peripherals based on pupil positions. Even though the usage of eye-tracking-based technology for enabling human-computer interaction for communication (Blignaut, 2017; Borgestig et al., 2021; Karlsson et al., 2019) or providing rehabilitation is common, its usage for fostering academic skills remains limited.

Furthermore, eye-tracking systems designed for communication are often prohibitively expensive for many individuals and frequently necessitate extensive customization. The primary objective of this study is to design and develop an affordable eye-tracking system tailored to the unique needs of paralyzed students. This technology enables them to use personal computers independently, ensuring access to educational resources and the ability to maintain their education. The significance of this study lies in its potential to revolutionize the educational experience for paralyzed students, who have long faced significant challenges in accessing and participating in traditional educational settings. Developing an eye-tracking system for controlling computers enables these students to access education independently and reduces their reliance on caregivers. This technology has the power not only to transform their educational experience but also to improve their overall quality of life and foster greater inclusivity in education.

METHODOLOGY

This study employed a design-based research methodology, which integrates design, research, and practical application (Wang & Hannafin, 2005). The research approach followed a systematic process comprising design, development, and evaluation stages, ensuring systematicity by adhering to specific steps (Richey et al., 2004). Design-based research was implemented in four phases: analysis, development, evaluation and testing, and documentation and reflection, as illustrated in Figure 1 (Reeves et al., 2004).

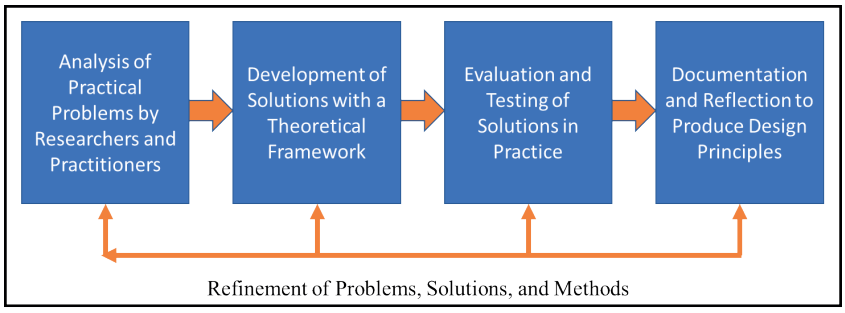

Figure 1. Design-Based Research Model by Reeves et al. (2004)

Participant Information

The study centered around a 23-year-old male participant actively pursuing his academic journey in the Physics Department. It's essential to highlight that his parents have played a crucial role in making his education possible. The participant faces unique challenges due to a diagnosis of Spinal Muscular Atrophy Type II (SMA2), a genetic disorder significantly affecting his control over voluntary muscle movements.

Spinal Muscular Atrophy Type II (SMA2) is a neuromuscular condition characterized by the progressive degeneration of motor neurons, resulting in the weakening of voluntary muscle functions. For our participant, this creates challenges in muscle coordination in his daily life and makes it difficult to engage in academic activities.

Apparatus

The solution developed for this study comprises a computer supported by the Windows operating system, an eye-tracking device, and computer control software, as illustrated in Figure 2. The computer, equipped with a 15.6-inch screen, is operated with an Intel Core i5 processor and 8GB of RAM to meet the minimum requirements of the eye-tracking devices used during this study.

Two low-cost eye-tracking devices, namely the Eye Tribe and Tobii EyeX, were employed throughout the study, maintaining similar sampling rates. The sampling rate defines how frequently the system records eye movement within a specific time frame, typically measured in Hertz (Hz). The Eye Tribe recorded eye movements at a 60 Hz sampling rate, while the Tobii EyeX operated at 70 Hz. During the development phase of this study, the Eye Tribe eye-tracker was utilized to capture eye movements. Subsequently, the Tobii EyeX eye-tracker was employed during the evaluation and testing phase for the same purpose due to its higher sample rate.

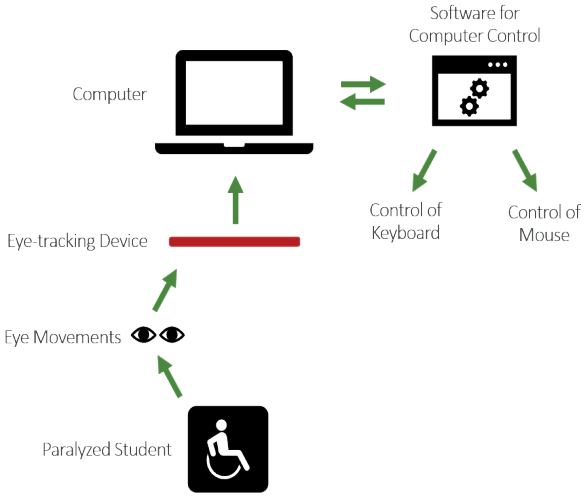

Figure 2. System Flow Diagram

The Procedure of the Study

The initial planning of this study commenced with a help request from the instructor of the paralyzed student, the participant of this study. Following the help request, the first phase of this study started with analyzing the problem. During this phase, interviews with the instructor, the paralyzed student, and his parents were conducted to understand the situation before designing and developing the optimal solution. The interviews aimed to determine the basic needs of the user. Subsequently, a review of existing technologies and current literature was conducted to align the student's needs with the capabilities of available technology. Based on the results of the first phase, the researchers determined to use eye-tracking technology in the solution to be developed for the paralyzed student.

In the second phase of this study, which is dedicated to developing the solution, the researchers focused on the initial planning of the solution that can help the student provide educational accessibility by using eye-tracking technology. The Eye Tribe eye-tracking device was used in this phase because of its affordable price. An iterative and incremental development process was employed during this study phase, as depicted in Figure 3.

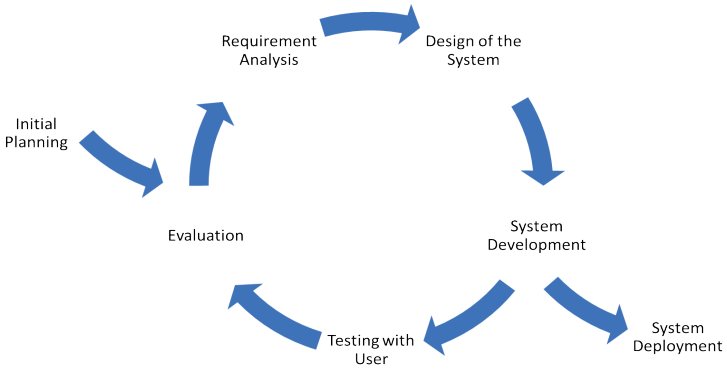

Figure 3. Development Process of the Solution

The iterative and incremental development process was executed in four cycles, outlined in Table 1. The initial cycle spanned seven weeks. In this first cycle, the interview results of the first phase of this study were used to determine system requirements. Then, the design and development of the solution were realized in four weeks. It was followed by a meeting with a paralyzed student to conduct a user test and interview. The researchers then evaluated this user meeting to provide input for the second cycle of the development process.

Table 1. Iterative and Incremental Development Process of the Study

# of the Development Cycle	Process	Duration
Development Cycle 1	Requirement Analysis	1 week
	Design and Development	4 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Development Cycle 2	Analysis, Design and Development	2 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Development Cycle 3	Analysis, Design and Development	3 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Development Cycle 4	Analysis, Design and Development	5 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting

After completing the first cycle of the development process, three additional cycles were implemented by following the stages of analysis, design and development, user test and interview, and user meeting evaluation, as outlined in Table 1. The second cycle spanned four weeks, while the third cycle lasted five weeks. Lastly, the fourth cycle lasted seven weeks. Consequently, the second phase, the development phase, employed an iterative and incremental development process and took fourteen weeks to complete. The outcome of this phase was the identification of design principles for developing an eye-tracking-based system tailored for paralyzed students to enable independent use of their personal computers.

In the third phase of this study (see Table 2), the evaluation and testing phase, the developed solution was used by the paralyzed physics student for two semesters, spring and fall. During these two semesters, he frequently used the developed solution for academic purposes and beyond. Additionally, he used this system for various extracurricular activities, social interactions, leisure activities, and more.

Moreover, four more cycles were deployed to finalize the proposed solution during this phase (see Table 2). The Tobii EyeX eye-tracking device was used in this phase because it was affordable and a widely used brand. The first finalizing cycle started with analyzing individual usage during two semesters. Then, it was followed by design and development, user test and interview, and evaluation of the user meeting. It lasted ten weeks. Following the completion of the initial cycle, three additional cycles were implemented, which involved (1) analysis, design, and development, (2) user testing and interviews, and (3) evaluation of the user meeting. Then, both the second and third finalizing cycles lasted eight weeks. Lastly, the fourth finalizing cycle lasted six weeks. Consequently, during the third phase, the development phase, two main processes were undertaken: testing and finalizing cycles. Testing spanned two semesters, while finalizing cycles took place over a period of thirty-two weeks. As a result of this phase, the proposed solution, an eye-tracking-based system for paralyzed students to enable them to use their personal computers for mainly academic purposes, was finalized.

Table 2. Evaluation and Testing Phase of the Study

Cycle of the Phase	Process	Duration
Testing	Individual Usage	2 semesters
Finalizing Cycle 1	Analysis of Individual Usage	2 weeks
	Design and Development	6 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Finalizing Cycle 2	Analysis, Design and Development	6 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Finalizing Cycle 3	Analysis, Design and Development	6 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting
Finalizing Cycle 4	Analysis, Design and Development	4 weeks
	User Test and Interview	1 meeting
	Evaluation of the User Meeting	1 meeting

In the fourth phase, the documentation and reflection phase, design principles obtained at the end of the second phase were finalized and documented according to the results of the third phase, the evaluation and testing phase.

FINDINGS

The design and development of the solution in this study progressed through four phases: analysis, development, evaluation and testing, and documentation and reflection.

Analysis Phase

At the outset of the analysis phase, interviews with the paralyzed student, his instructor, and his parents were conducted to understand the basic needs of our target user, the optimal requirements for the solution to encourage academic achievements, and the role of the caregivers in our participant's academic life. According to the interview with our target user, a paralyzed student, it was noted that he participates in face-to-face

courses with the help of his parents by using his wheelchair. He does not have any problems with hearing or vision. He could participate in classes and follow the lessons. He has a room in the department to rest and study between his courses. He stays in a dormitory with his mother. Based on the interview with his instructor, we discerned that there are two sides to taking a course: following the lesson in class, watching video-based lessons, and using supplementary course materials provided by the university's Learning Management System (LMS). According to the interview with his parents, we gathered that her mother helps our student study using both printed materials and personal computers. The student instructs his mother on what to do, and she executes the tasks.

Moreover, the fundamental usage of a computer was analyzed during this phase. A computer has two primary input devices. One of them is a mouse that enables users to reflect the up, down, left, and right moves as the cursor moves on the computer screen. In other words, by using a mouse device, users can move the cursor on the screen wherever they want. For example, they can move the cursor on an icon of an application. Then, they need to use the click function or the double-click function on the mouse device to open the application. In addition, one of the most commonly used functions of a mouse device is the right-click option, which enables users to see preferences based on the cursor's position on the screen.

In conclusion, the mouse serves as a compulsory input device for a computer, offering functionalities such as up, down, right, and left movements of the cursor and click, double-click, and right-click functions. The other compulsory input device of a computer is the keyboard, which enables users to write letters, numbers, and symbols or to use keys or combinations of keys by pressing simultaneously to send different commands to the computer. In simple terms, it requires pressing one or more keys to use the keyboard as the input device of a computer. Therefore, our focus during solution development was to simulate the actions of two key input devices, namely the mouse and keyboard, solely through the user's eye movements.

As a result, the researchers of this study decided to concentrate on after-class activities and provide a solution for our participant to use in both of his rooms, at the department and dormitory. The solution was built on eye-tracking technology, creating a computer-based system solely controlled by the user's eye movements. It provided an opportunity for paralyzed students by enabling them to use all of the functions of a computer with eye movements using the developed system, which consisted of an eye tracker device, a laptop, and software.

Development Phase

In this phase, the iterative and incremental development process was applied in four cycles. At the beginning of the first cycle, the requirement analysis was employed based on the results of the first phase. It was decided to develop a solution for our participant that includes a laptop, an eye-tracking device, and software. The eye-tracking device, the Eye Tribe, was chosen as an input source to collect the eye movements of the user as x and y coordinates on the screen. Its sampling rate is 60 Hz, and nine-point calibration was applied before using the system. Subsequently, the system responds to the user according to his eye movements. For the first cycle of the development phase, an application was developed with limited features. The application enabled the user to move the cursor on the screen using eye movements. Additionally, buttons for numerical and alphabetical keys were present on the screen. Throughout the user testing and interview process, the goal was to observe and confirm that the user could manipulate the cursor with their eye movements and accurately position it over the buttons.

In the second cycle, the utilization of eye movements to emulate both keyboard and mouse functions was established. While replicating keyboard functions, smartphone and MS Windows on-screen keyboards were combined based on the user's needs. For instance, two tabs, one for alphabetical and MS Windows-based keys and the other for numerical and frequently used symbol keys, including a key (named ABC/.?123) to switch between tabs, were included in the design. A suitable and practical design was made by having a limited number of keys in the keyboard in order not to reduce the size of the keys and not to take up too much space on the screen. Three options were identified to replicate the mouse's click function, drawn from current literature and technology. The first was to set a focus duration on a key to run the click function. The click function would be called if the user focused on the key and kept his focus for a specific time. The second one was based on voice commands, where the user needed to speak a predefined word for the click

function. The third one relies on intentional blinking rather than a reflex. To execute a click, the user needs to close their eye for a specific duration and then reopen it. All three options were reviewed and tested by considering the user's needs. Then, it was decided to use the third option, blinking, because it resulted in better and quicker user performance. Initially, an attempt was made to execute a click by blinking one eye, with one eye open while the other remained closed. In essence, the eye-tracking data from the eye tracker would gather data from either the left or right eye for a specific duration, resulting in a click. During the trials, it was detected that if the user closes one of his eyes, the eye movement data from the other eye could be corrupted by the user's eyelashes. Thus, it negatively affected the effectiveness of the click function. As a result, it was decided to use blink for both eyes to perform a click by adding a function to distinguish it from blinking as a reflex. The user test was applied at the end of this cycle, followed by an interview. By using the results of the user test and interview, the third development cycle was planned.

In the third cycle, various mouse functions were on the target based on the user's needs. New gestures were designed to be tested with the user's eye movements. At first, a replication of the mouse drag function was designed to move the keyboard on the screen, providing flexibility for the user. A key to move the keyboard was added to the on-screen virtual keyboard, and then two functions were assigned to this key. When the user clicks on this key for the first time, the first function starts, and the on-screen virtual keyboard starts moving in line with the mouse cursor, with eye movements. Therefore, the user could move the on-screen virtual keyboard on the screen. Then, the user could do another click to release the on-screen virtual keyboard wherever s/he wants on the screen as the second function of the move keyboard key. Similarly, a key for enabling a right click was added to the on-screen virtual keyboard. After clicking on this key, the following first click would function as a right click. After that, the double-click function was planned in a similar way to the click function. As we designed and developed a function for clicking in the second phase, the user could blink both of his eyes to click. In other words, the click function runs if the user closes his eyes and opens after a specific time. In addition to this function, the mouse double-click function was designed to activate if the user keeps his eyes closed for twice the duration needed for the regular click function. Moreover, sound notifications were identified for click and double-click to indicate that the time needed for the click had elapsed. Three sound notifications were incorporated to provide auditory guidance for click and double-click functions. A trigger monitored the eye movement data, initiating a countdown if the data flow ceased. The first sound is played when the time reaches the predetermined duration, for example, two seconds. The trigger runs the click function if the user opens his eyes after hearing this sound. If the user keeps his eye closed until hearing the second sound played after a certain time, for example, two more seconds later and opens his eyes. Then, the trigger runs the double-click function. If the user keeps his eye closed two more seconds after hearing the second sound, the third sound is played to indicate that there was no data flow for a long time, the trigger would stop running, and no action would be taken, like a click or double-click. Moreover, before the user closed his eyes, the screen coordinates were recorded to execute click functions after he opened his eyes. This approach accounted for potential differences in the user's eye movements before and after closing his eyes. Therefore, the x and y coordinates on the screen before closing his eyes were kept and used while performing the click function, even though he looked at different positions on the screen after opening his eyes.

In addition to click and double-click functions, the mouse scroll functions (up and down) were also assigned to the keys, which were added to the on-screen virtual keyboard. Furthermore, the print screen key function was modified to exclude the on-screen virtual keyboard from the screenshot. When the user clicks on the print-screen key, these three functions run sequentially: a function to minimize the on-screen virtual keyboard window, a function to take a screenshot, and a function to restore the minimized keyboard window.

At the end of this cycle, a user test with a working on-screen virtual keyboard (see Figure 4) was applied, followed by an interview. The fourth and last development cycle was planned using the user test and interview results.

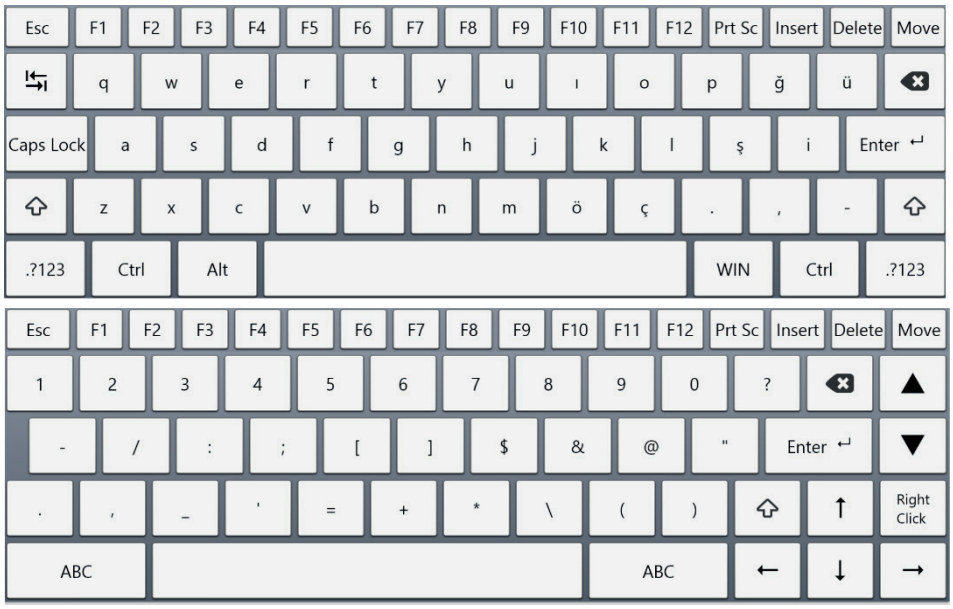

Figure 4. On-screen Virtual Keyboard Developed During the Third Cycle

In the fourth cycle, the overall design of the keyboard was revised to enhance effectiveness and efficiency for the user. To this end, one more line of keys was added at the top of the on-screen virtual keyboard. On this line, there were four groups of keys to provide more comfort.

In the first group, three options were provided for the user to change the duration to keep his eyes closed to perform mouse functions such as click and double-click. By providing this option, it was assumed to give him a chance to use the system quicker as he gained experience. Alternatively, he could use it more slowly when he is a beginner. So he could adjust the duration to click or double-click, depending on his own pace.

In the second group, five options, namely select all, cut, copy, paste, and undo, which require two simultaneous key presses to perform, were added to the on-screen virtual keyboard. This addition aimed to simplify the user process of selecting these functions.

In the third group, two keys were added to increase and decrease the opacity of the on-screen virtual keyboard to make it possible to see the area behind the keyboard. In the fourth and last group, two keys were added, one to minimize the on-screen virtual keyboard and the other to exit, which were not used at first to save space.

Additionally, numeric keys were placed on both tabs for ease of use by putting function keys (F1, F2, F3, etc.) only in the tab consisting of keys for symbols. In parallel to this change, the name of the ".?123" key was replaced with ".+?@". At the end of this cycle, a user test with the developed on-screen virtual keyboard (see Figure 5) was applied, followed by an interview to observe and examine the changes made during this cycle.

Figure 5. On-Screen Virtual Keyboard Developed During the Fourth Cycle

Evaluation and Testing Phase

The developed solution tracks the eye movements of the user and turns them into mouse cursor movements. Moreover, it provides an on-screen virtual keyboard with easy-to-use functions for enhancing interactivity by enabling key press events with the combination of eye movements and eye blinking. This study demonstrated that our target user could successfully engage in computer-based activities to meet his course requirements. The solution not only facilitated independent task performance but also boosted the user's motivation by empowering him to carry out activities autonomously.

During this phase, the paralyzed Physics Department student used the system (see Figure 5) for two consecutive semesters (spring and fall). In the first semester, he registered for three courses, all of which were must-courses. Two were departmental courses, while one was a language course from the foreign languages department. In the second semester, he registered for three must courses again. Two were departmental courses, while one was from the mathematics department. He used the developed solution during these two semesters while actively pursuing his education. He used his computer by himself and did anything that could be done with a computer, such as doing homework or searching for online course materials. Besides, he can easily follow e-mails and class discussions related to his courses, research via the Internet, and reach resources for his personal development. He stated that this solution provided him motivation and a chance to self-control his education by saying: "I can use my computer without the help of my mother.", "I can do anything that can be done on the computer. Awesome!" and "I could write pages of codes with this system in the programming course that I will take next semester."

Figure 6. Solution Developed for the Paralyzed Student

Furthermore, an additional four finalizing cycles were conducted over two semesters, each tailored to the individual use of the proposed solution. In the first cycle, the number of frequently used keys increased based on the user's needs by altering numeric keys on the symbols tab of the on-screen virtual keyboard. Besides, two more keys, one for starting the task manager and the other for performing the function of the "ALT+F4" key combination, a shortcut to close the currently active window, were defined in the symbols tab. At the end of this cycle, a user test was applied, followed by an interview to observe and examine the changes made during this cycle.

In the second cycle, the mouse-over function was defined for the keys of the on-screen virtual keyboard to highlight the key the user is looking at. Moreover, the keyboard move function was limited to two predetermined positions on the screen, one at the center top and the other at the center bottom, to prevent accidentally moving the on-screen virtual keyboard to the unwanted positions. In parallel to this, the keys for increasing and decreasing the opacity of the keyboard were combined, and it was assigned to set the opacity to four predefined values at every click. Furthermore, a key was defined to execute the drag function of the mouse. Upon activation of this key by the user through a click, the subsequent two clicks would execute the mouse's left button down and up actions sequentially. At the end of this cycle, a user test with the final version of the on-screen virtual keyboard (see Figure 6) was conducted, followed by an interview.

In the third cycle, improvements were made to enhance the precision of moving the mouse cursor on the screen using eye movements. Cursor movements were executed based on the average eye positions obtained from the eye-tracking device. For instance, the Tobii EyeX eye-tracking device has a frequency of 70 Hz, indicating how many times per second the eye tracker registers the position of the eyes, and nine-point calibration was applied before using the system. For this device, the average of the last thirty eye positions was used to move the mouse cursor on the screen. In this cycle, the number of eye positions used to calculate the average to move the mouse cursor was defined to be updated automatically depending on the saccades in the eye movement. When the user attempted to fixate on the screen and their eye movements were concentrated in a narrow space, the value utilized to compute the average of eye positions was elevated to facilitate smoother cursor movements on the screen. Conversely, if the saccade's amplitude was longer, the value used to calculate the average of eye positions was decreased to facilitate more rapid cursor movements on the screen. This adaptive approach aimed to optimize cursor control based on the user's specific eye movement patterns.

Figure 7. On-screen Virtual Keyboard

In the fourth cycle, the focus shifted towards enhancing comfort during reading or watching activities, where cursor movement or clicking is not required, and even the on-screen virtual keyboard might be unnecessary. It was resolved by adding a function to pause mouse functions by eye movements and removing the on-screen virtual keyboard from the screen by deactivating the eye-tracking feature. This function had two consecutive steps: the first was to minimize the on-screen virtual keyboard using the minimize key, and the second was to stop the flow of eye movement data for three seconds by consciously closing the eyes. To activate the eye-tracking feature, the user needs to close his eyes for three seconds again. Then, the eye-tracking feature could be used with all of its functions.

At the conclusion of this cycle, a user test with the finalized on-screen virtual keyboard was applied, followed by an interview to observe and examine the final version of the on-screen virtual keyboard.

Documentation and Reflection Phase

In the documentation and reflection phase, design principles obtained at the end of the second phase were finalized and documented according to the results of the third phase, the evaluation and testing phase. The finalized design principles were addressed in the discussion. The design principles that emerged during this study are listed below.

The eye movement-based computer control system should:

Be designed to move the mouse cursor based on the user's eye movements.

- Set the speed of mouse cursor movements based on the saccade's amplitude of eye movements adaptively instead of straightforward mouse cursor movements.
- Have various options to perform mouse functions, such as click and double-click, depending on the user's needs and capabilities. Mouse functions can be performed by using the following:
  - Option 1: focus duration of the user's eye movements for a specific time
  - Option 2: predetermined voice commands
  - Option 3: eye blink for a specific time as it is decided to prefer while developing the solution during this study
- Have easy-to-use methods for frequently used mouse functions such as click and double-click, as it is implemented by closing eyes for one second for click and two for double-click during this study.

- Provide relative flexibility for the user to select the best duration to close their eyes for a click or double-click based on their own pace.
- Provide feedback with sound notifications to guide the user when their eyes are closed while performing specific functions, such as clicking or double-clicking.
- Keep the eye positions of the user before closing the eyes and perform the intended functions based on these eye positions; even the eye positions change while blinking the eyes.
- Include on-screen virtual keyboard keys for various mouse functions, such as right-click, scroll, and drag-and-drop.
- Offer shortcuts on the on-screen virtual keyboard for frequently used functions that require multiple key presses or mouse clicks, such as select all, cut, copy, paste, task manager, and close the currently active window (ALT+F4).
- Have a simple design and easy-to-use on-screen virtual keyboard to ease and enable the user to move eye positions to intended positions on the screen without taking up too much space.
- Enable the user to change the position of the on-screen virtual keyboard around the screen between predefined positions.
- Have options to change the on-screen virtual keyboard's opacity and minimize the keyboard if more space is needed on the screen.
- Enhance user-friendliness, visibility, and focusability by implementing a color-coded system for key groups on the on-screen virtual keyboard. Additionally, employ a feature that highlights keys when the user's eye movements hover over them.
- Provide an option to enable and disable the on-screen virtual keyboard and eye-tracking-based mouse control when necessary.

DISCUSSIONS

This study focused on designing and developing a solution that enables complete computer control solely through eye movements, providing an opportunity for physically disabled individuals, such as paralyzed students, to participate in courses with minimal external assistance. The aim was to offer comprehensive educational accessibility for paralyzed students, allowing them to engage in both in-class and online activities independently.

The participant in this study, a paralyzed student from the Physics Department, was able to pursue his undergraduate education with the help of his parents. The participant joined his courses, including both in-class and online activities via the Learning Management System (LMS). Before this study, he was joining in-class activities by wheelchair with the help of his parents, and he was getting help from his parents for online activities like reaching online sources to study, doing homework, typing, taking exams, joining class discussions, etc. During this study, he was asked to use the eye-tracking-based solution for course activities such as preparing homework and accessing/using internet resources. Additionally, he willingly chose to use the system.

When compared to existing systems like Tobii Dynavox (https://www.tobiidynavox.com), the solution developed during this study offers a cost-effective means of communication with the computer. Moreover, the system was tailored and individualized during the study to meet the participant's specific needs, ensuring a perfect fit.

This study has uncovered design principles that facilitate paralyzed students in taking courses through the developed solution. In this study, mouse and keyboard functions were simulated to provide paralyzed users with a solution that does not require physical interaction with these input devices. People with physical impairments can have difficulties properly interacting with input devices, so they need alternative ways to use these devices to control computers (Abiyev & Arslan, 2020; Borgestig et al., 2021; Hemmingsson & Borgestig, 2020; Lupu & Ungureanu, 2014; Raya et al., 2010)what reduces their possibilities to communicate and improve their cognitive and physical skills through computers. This paper proposes a head control mouse based on a triaxial inertial sensor particularly focused on infants with cerebral palsy (CP.

As demonstrated by Galante and Menezes (2012), it is possible to provide digital communication boards consisting of symbols to identify words or ideas to provide a communication method for physically disabled people. It is essential to offer preferences depending on their abilities and habits while developing an eye gaze solution for paralyzed students. In this study, complete control of a computer-based communication solution was developed by simulating mouse and keyboard functions via eye movements.

According to Lin et al. (2011), mouse movements could be provided in line with the eye movements, and various options such as duration to click, eye-movement-based, and voice-controlled options can be offered in an eye-controlled system. In parallel to the study of Zhang et al. (2017), the current study identified mouse functions that require two steps to complete, such as right-click, drag-and-drop, and scroll, as a keyboard key's function, while single-click (left-click) and double-click functions were performed by using only eye gaze.

During the design of the on-screen virtual keyboard in this study, it was imperative to incorporate shortcuts for frequently used functions and to maintain a simple design for the on-screen virtual keyboard, aligning with the approach described in Blignaut (2017) for easy accessibility. According to Caligari et al. (2021), setting the appropriate duration to select a key press is one of the most critical considerations in using an on-screen virtual keyboard with eye movements. In parallel to this finding, the current study offered options to set the duration of the dwell click time for pressing the keys of the on-screen virtual keyboard using eye gaze.

CONCLUSION

This study has demonstrated that the system has the potential to elevate the accessibility of both face-to-face and online education to a new level, particularly benefiting paralyzed students. Online education provides opportunities for students who may not be able to attend classes physically. Even the description of online education fits the paralyzed students; in reality, it is not possible for these students to reach online courses. Therefore, this study showed that eye-tracking technology could help fill the missing part of face-to-face and distance education for paralyzed students.

By leveraging eye-tracking technology, paralyzed students can overcome physical barriers and actively engage in online courses, interact with peers and instructors, and independently pursue learning through Internet services. The system's potential extends beyond the confines of traditional education, offering a transformative solution for paralyzed students to participate in various educational activities.

It's important to note that this study is limited to one participant with SMA2, and students with different needs may require individualized modifications to the developed system. Consequently, the design principles uncovered in this study can serve as a valuable guide for the development of systems tailored to the specific needs of paralyzed individuals, ensuring a more inclusive and adaptive approach to education technology.

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INNOVATIONS IN ASSESSING STUDENTS' DIGITAL LITERACY SKILLS IN LEARNING SCIENCE: EFFECTIVE MULTIPLE CHOICE CLOSED-ENDED TESTS USING RASCH MODEL

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ABSTRACT

This research goal to develop a multiple-choice closed-ended test to assessing and evaluate students' digital literacy skills. The sample in this study were students at MTsN 1 Blitar City who were selected using a purposive sampling technique. The test was also validated by experts, namely 2 Doctors of Physics and Science from Yogyakarta State University. The test instrument was developed based on five aspects of digital literacy skills: information, communication, content creation, security and problem-solving. Data have been analyzed descriptively and inferentially using the Rasch version and the assist of Quest software. The results showed that eight multiple-choice closed-ended test instruments were declared valid based on expert validation with an Aiken V value of 1.00. The reliability result is 0.97 with a very high category, and the INFIT MNSQ standard deviation value is 0.86 - 1.16, so seven items are by the Rasch model. Thus, the seven items in the multiple-choice closed-ended test instrument can be used to assessing and evaluate students' digital literacy skills in learning science.

Keywords: Closed-ended test, digital literacy, science learning, rasch model.

INTRODUCTION

In the modern era marked by the rapid advancement of digital technology, digital literacy has become essential for individuals to participate actively in an increasingly technologically connected society (Muhali, 2019; Nicholson, 2017). The increased use of digital devices and online platforms in various aspects of life has strengthened the importance of mastering digital literacy skills, especially among students, for future provision (Mardhiyah et al., 2021; Rahayu et al., 2022; Reddy et al., 2023). The increased use of digital technology in various aspects of life has confirmed the importance of mastering digital literacy skills for students and has an impact on education (Chetty et al., 2018; Churchill, 2020).

Technological developments have changed the paradigm of traditional learning. This is in line with the transformation of education driven by technology. Students not only understand academic material, but must also be able to interact with digital technology, understand online information, and think critically about widespread digital content (C. Hague & Payton, 2021; Tang & Chaw, 2016; Tristiana & Kayyis, 2022). Digital literacy involves utilizing technology to access, acquire, understand, analyze, evaluate, create and communicate knowledge in various contexts (Alexander et al., 2016; Dwyer, 2023). Learners need to develop skills in understanding the content of technology-based digital media contexts to become better

prepared to live and interact in a digital-based society (Erwin et al., 2022). Digital literacy is understanding and using information from various sources widely accessed via computers (Gilster, 1997).

Learning using digital media can make students have an attitude of understanding, appreciating and being involved in social interaction and collaboration, interpersonal and communication skills, this is because the media can be used flexibly and is able to create interaction (Gilpin, 2020). When using social media, you must have digital literacy skills because when using media, students are required to be creative and create learning experiences (Romero-Hall & Li, 2020). Schools all over the world need digital literacy skills in learning for both teachers and students because digital literacy can help teachers and students develop their critical thinking skills in dealing with situations (Coker, 2020).

The results of initial observations, most students can operate digital devices such as smartphones. However, students need help using various applications and platforms to facilitate learning, such as Google Meet and Google Classroom. Even though there are efforts to use digital technology, some students still need help to complete assignments, even though digital technology has been involved. The digital literacy skills possessed by students at MTsN 1 Blitar City can be described as having mastery over technological developments, where they have skills in using digital media in learning contexts. However, there still needs to be more understanding of using digital media for educational purposes and the ability to manage and interpret information obtained through digital media.

In addition, the problem is that most schools still need to thoroughly teach digital literacy as a basis for literacy, which is equivalent to literacy in reading, arithmetic and writing (Coffin Murray & Perez, 2014). Research that has been conducted has found that the level of digital literacy skills of students is classified as moderate (Ussarn et al., 2022). In addition, currently, Indonesia has begun to develop students' digital literacy skills; this is evidenced by the existence of several efforts from educators, beginning with the use of gear in gaining knowledge of, the use of digital media in training, then additionally analyzing the effect of virtual literacy in information, digital literacy, digital competence, digital literacy abilties, digital collaboration, digital generation, literacy, generation, pc literacy, and others (Ibda & Syamsi, 2023; Ibda et al., 2023).

Developing adequate test kits is essential to assessing students' digital literacy skills. In learning, a test or question can be grouped into two: closed-ended and open-ended. Closed-ended such as true-false, multiple choice, and matching. At the same time, open-ended are free-response, short answer, and essay writing (Brassil & Couch, 2019). Multiple choice tests contain several questions to be answered by test takers whose answers are clear, right and wrong, and there is only one correct answer (Sukendra & Atmaja, 2020). Objective tests have several advantages. That is, the coverage of material on objective tests is relatively broad, the level of validity and reliability is very high, and it can be used for many participants (Widiyanto, 2018).

Closed-Ended questions in a survey or questionnaire require respondents to choose answers from a predetermined set of choices (Klofstad, 2005). Closed-ended is more accessible online because it requires only one button or response but can bias the reaction (Connor Desai & Reimers, 2019). The advantages of closed-ended are that respondents can answer questions quickly, it's easier to answer, and the data obtained is faster to analyze (Hyman & Sierra, 2016).

The Rasch model is a statistical model used to develop test items and provide information relevant to student learning progress (Boone, 2016). Analysis using the Rasch model can increase reliability and validity due to the separation with the diagnosis of analysis of items suitable for use and samples not eligible for use (T. Bond, 2015). When used in testing data collection instruments, research using the Rasch model can produce precise and accurate data analysis (Rabbitt, 2018; Bambang Sumintono, 2018).

This instrument can provide an overall picture of the extent to which students have digital literacy skills. In addition, this instrument can also assist in designing a curriculum that is more in line with the demands of 21st-century digital literacy. Considering the current global context where technology is increasingly penetrating every aspect of life, innovation in measuring students' digital literacy skills is essential in shaping young people ready to face future challenges.

Based on this description, the hassle in the area is figuring out the extent of digital literacy competencies of junior high school students. So it is necessary to research developing evaluation instruments to assessing and evaluate students' digital literacy abilities. This research aims to create a multiple-choice closed-ended

test instrument to measure and assess digital literacy skills that are valid, feasible, and reliable. The results of this study can be the basis for measuring students' digital literacy skills. Thus, this research can contribute to education development in Indonesia.

METHOD

This research is quantitative research with a survey method. This study aims to develop a multiple choice closed-ended test to assessing students' digital literacy skills. The effects of this study can be the premise for measuring college students' virtual literacy talents. statistics had been analyzed descriptively and inferentially with the Rasch model the use of Quest. Analysis the usage of the Rasch version is used to expect missing object statistics primarily based at the consequences of response styles (B. Sumintono & Widhiarso, 2014).

Participants

The research sample was MTsN 1 Blitar City students, with a total sample of 127 students and two doctors Yogyakarta State University. The sample selection technique is purposive sampling.

Data Collection and Analysis

The first stage in developing the test is defining digital literacy skills and synthesizing digital literacy ascpects from several experts used in developing the test. The aspects used in the post-modification test are internet searches, hypertext guides, content and information evaluation, and knowledge compilation. According to Gilster (1997), digital literacy aspects are internet searching, hypertextual navigation, content evaluation, and knowledge assembly. According to Bawden (2008), digital literacy aspects are content evaluation, hypertext navigation, knowledge assembly, and internet search. Meanwhile, according to Hague and Payton (2013), aspects of digital literacy are functional skills and beyond, creativity, collaboration, communication, e-safety, critical thinking and evaluation, and the ability to find and select information. Aspects from several experts were synthesized and modified to produce several aspects used in this research. The indicators resulting from modification of these aspects are arranging ways of searching for information from the media, optimizing directions in the media, clarifying the truth of the information content, assessing the suitability of the information content, and building new knowledge. At this stage, it also carried out the preparation of research instrument drafts. At this stage, we start compiling a multiple-choice closed-ended instrument grid. The draft instrument that has been made will be assessed by experts to see the suitability of the aspects with the tests on each instrument item. The test developed is a multiple choice closed-ended test with 13 items. This test is to assessing students' digital literacy skills. There are four choices for each question.

The stage is submitting content validation which is carried out by 2 Doctors who are experts in their fields. The instrument for assessing content validity is an assessment sheet filled in by the validator. The assessment sheet contains valid and invalid aspects with a concordance between the question items and digital literacy aspects, accompanied by a column for suggestions and comments. The scale used in assessing validity uses a Likert scale with a level of 5 (Likert, 1932). The content validation stage was carried out by 1 Doctor of Physics and 1 Doctor of Science from Yogyakarta State University, who were asked to review 13 item questions. The validator assesses the question items based on the digital literacy test criteria on the validation sheet. The validation sheet has been tested for the validity of the instrument. The validators report their validation results and provide feedback on items they think require revision, and all necessary revisions have been made.

Content validation is the stage that indexes the validity of the test to measure what is to be measured (Cheng et al., 2021). Content material validity is related to whether the items in the test constitute the components of the content material of the material being measured or the quantity to which the object is by using the factors being measured (Azwar, 2012). Items that meet the standards and requirements will pass, but items that do not meet the criteria will be discarded (Ayre & Scally, 2014). The validation sheet is filled using a Likert Scale with five scales. The scores obtained from the validation results were analyzed statistically to determine content validity based on expert agreement with Aiken's validity content. Determination of Aiken's validity content by comparing the assessment of one item assessed by n raters with a value range of V

from 0-1. Aiken's validity content is an index of expert agreement on the suitability of the indicator items to be measured using these items. Aiken's validity content formula is as follows (Aiken, 1985).

$$V = \frac{\Sigma s}{[n\,(c-1)]}$$

$$s = r - lo$$

In which r is the category score given by means of the rater, lo is the lowest score in the scoring class, c is the number of categories the rater can pick out from, and n is the range of validators or raters. The product content material validity criteria had been decided based on Aiken's V , as presented in Table 1.

Table 1. The minimum value of Aiken's V

No. of Items (m) or Raters (n)	Number of Rating Categories (c)											
	2		3		4		5		**6**		**7**	
	V	p	V	p	V	p	V	p	V	p	V	p
1							1.00	0.040	1.00	0.28	1.00	0.020
2							1.00	0.008	1.00	0.005	1.00	0.003
3			1.00	0.37	1.00	0.16	0.92	0.032	0.87	0.046	0.89	0.029

Then perform the examine via growing a multiple choice closed-ended tool layout on Google forms. This goals to make it easier for college students to fill inside the device. An analysis of empirical tests or field exams is achieved to decide the characteristics or validity of the gadgets. Item evaluation turned into performed with the assist of an object evaluation program, the hunt software. Object evaluation turned into finished to decide the reliability and trouble stage of the gadgets. The items will healthy in the event that they comply with the Rasch version, with the INFIT MNSQ price being between 0.77 – 1.33 and the OUTFIT t ≤ 2 with a chance of 0.5. Evaluation the use of the Rasch version has the gain that there's a level of man or woman potential or settlement, and the level of issue of the objects to be authorized can be defined with a statistical precis.

FINDINGS

In this section, the research results are presented. the results of research on Digital Literacy Multiple Choice Closed-Ended Test Aspects are presented in Table 2. Meanwhile, examples of development results can be seen in Figure 1.

Table 2. Digital Literacy Multiple Choice Closed-Ended Test Aspects

Aspects	Indicators	Items
Internet searching	Develop procedures for searching for information on the internet and digital learning media	1
		2
	Collect information from the internet and media effectively and efficiently	3
		4
		5
Hypertextual navigation	Optimizing hypertext navigation in digital learning media and websites	6
		7
Content evaluation	Clarify the validity and completeness of the information content obtained	8
		9
	Assess the appropriateness of the information content	10
		11
Knowledge assembly	Build knowledge from information	12
		13

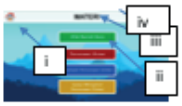
Aspek	Indikator	Indikator soal	Soal
	Mengumpulkan informasi dari internet dan media secara efektif dan efisien	Memilih sumber informasi untuk membuat karya tulis ilmiah	Yana akan membuat karya tulis ilmiah mengenai solusi untuk pemanasan global berupa mobil panel surya. Untuk membuat karya tulis yang baik, dia harus mencari sumber informasi terbaru. Agar hal itu dapat tercapai, maka yang perlu dilakukan Yana adalah.... A. menonton youtube, lalu menulis sesuai solusi yang ditunjukkan B. membaca blog tentang panel surya C. berdiskusi dengan teman di media sosial D. mengunduh hasil jurnal penelitian yang inovasi
Pandu arah (Hypertextual navigation)	Mengoptimalkan pandu arah (navigasi) hypertext dalam media pembelajara digital dan website	Memilih pandu arah untuk animasi efek rumah kaca	Perhatikan gambar di bawah ini!  Indah ingin memilih animasi efek rumah kaca. Petunjuk yang memudahkan untuk memilih animasi efek rumah kaca adalah.... A. i B. ii C. iii D. iv
		Menjalankan simulasi tentang efek rumah kaca	Perhatikan langkah-langkah menjalankan simulasi online efek rumah kaca pada website di bawah ini. i. Memilih topik yang sesuai dengan simulasi

Figure 1. Example of Digital Literacy Multiple Choice Closed-Ended Questions

The results of content validation carried out by experts can be seen in Table 3.

Table 3. Content Validation Results based on Aiken's V

Indicator	Sub Aspect	Items	V'Aikens _	V 'Aikens Per aspect	Category
Internet searching	Develop procedures for searching for information on the internet and digital learning media	1	1	1	High
		2	1		High
	Collect information from the internet and media effectively and efficiently	3	0.88	0.88	High
		4	0.75		Currently
		5	1		High
Hypertextual navigation	Optimizing hypertext navigation in digital learning media and websites	6	1	1	High
		7	1		High
Content evaluation	Clarify the validity and completeness of the information content obtained	8	1	0.94	High
		9	0.88		High
	Assess the appropriateness of the information content	10	0.88	0.94	High
		11	1		High
Knowledge assembly	Build knowledge from information	12	1	0.94	High
		13	0.88		High

The results of the Rasch model analysis using Quest are described in Figure 2 is a map of items and persons, Figure 3 shows the items' distribution based on their fit with the Rasch model, and Figure 4 of item difficulty level.

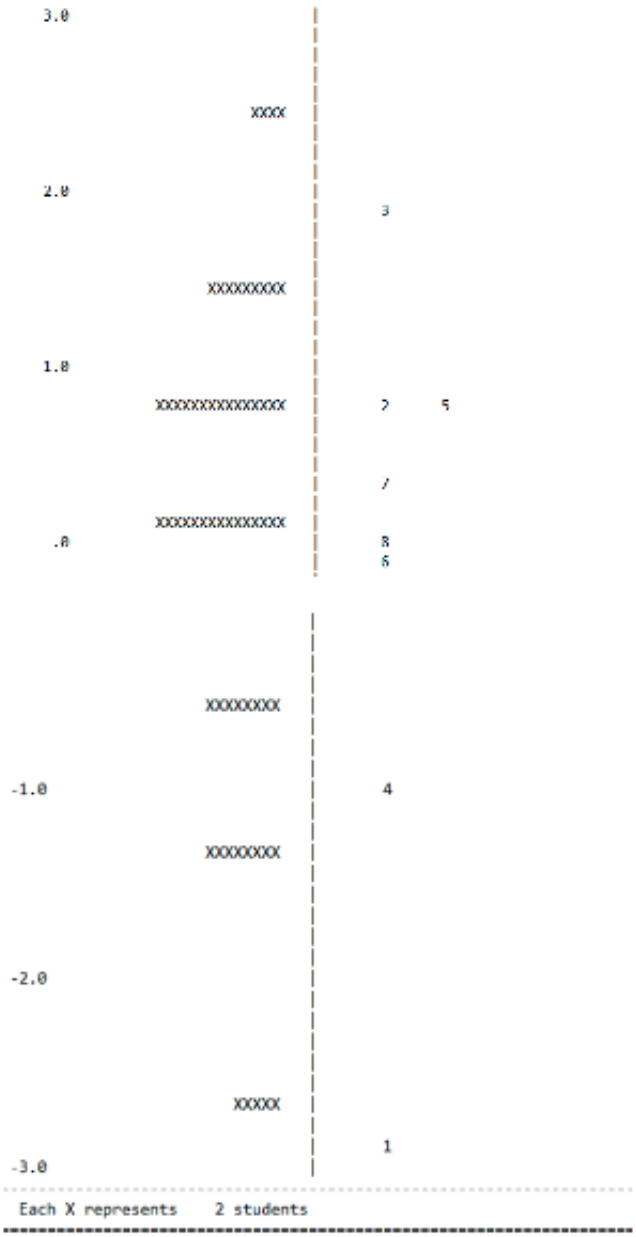


Figure 2. Item and person map

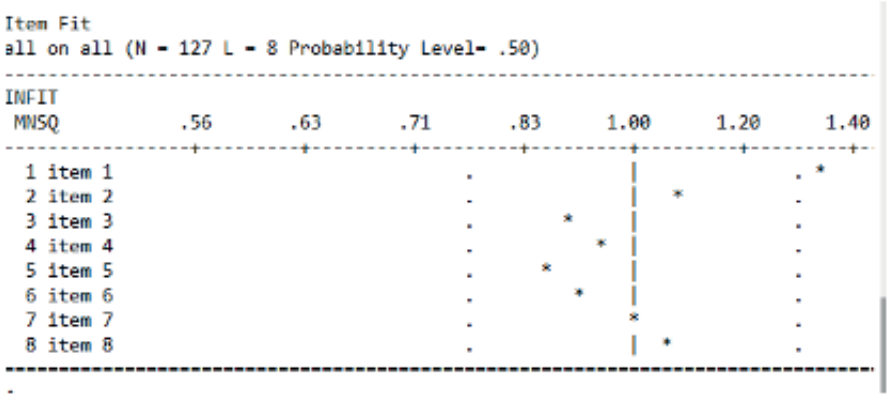


Figure 3. Distribution of items

	ITEM NAME	SCORE	MAXSCR	THRSH 1	INFT MNSQ	OUTFT MNSQ	INFT t	OUTFT t
1	item 1	116	127	-2.90 .40	1.33	2.01	1.2	1.3
2	item 2	44	127	.85 .21	1.07	1.10	.8	.5
3	item 3	21	127	1.92 .26	.89	.81	-.7	-.4
4	item 4	92	127	-1.08 .24	.95	.83	-.4	-.6
5	item 5	45	127	.81 .21	.87	.73	-1.6	-1.3
6	item 6	69	127	-.09 .21	.91	.83	-1.0	-1.0
7	item 7	55	127	.43 .21	1.01	1.06	.1	.4
8	item 8	65	127	.06 .21	1.07	1.05	.8	.4
Mean				.00	1.01	1.05	-.1	-.1
SD				1.46	.15	.41	1.0	.9

Figure 4. Item difficulty level

Table 4 describes the fit and misfit items. The manner to discover healthy and misfit gadgets is to evaluate the INFIT MNSQ value with the sum of the mean and preferred deviation values.

Table 4. Empirical Test Results or Reliability

Mean	SD	SD (adjusted)	Reliability of estimate	Infit Mean Square		Outfit Mean Square		Infit t		Outfit t	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
0.00	1.46	1.44	0.97	1.01	0.15	1.05	0.41	-0.08	0.98	-0.08	0.88

DISCUSSIONS and CONCLUSION

On this segment, it's miles explained the outcomes of research and on the equal time is given the comprehensive discussion. The dialogue can be made in numerous sub-sections.

Development of Multiple Choice Closed-Ended Tests

In an era characterized by rapid advances in digital technology, digital literacy has become necessary for individuals to participate effectively in a modern, increasingly technologically connected society. With the increasingly widespread use of digital devices and internet access, digital literacy skills are fundamental in accessing, understanding, and interacting with digital information. Therefore, developing effective measurement instruments to assessing students' digital literacy skills is becoming increasingly important, especially in education, which is increasingly integrated with technology.

Within the scope of education, educators and educational institutions are responsible for preparing students to face an increasingly technologically connected world. Effective digital literacy assessingment instruments will help identify areas where students need to improve in terms of digital literacy skills. In addition, this instrument can also guide educators in designing learning that is more relevant to the demands of 21st-

century digital literacy. In growing this instrument, important elements of digital literacy, which includes the capability to use technology, apprehend statistics severely, and think creatively in a virtual surroundings, had been considered.

The Digital Literacy ability of students currently needs to improve. consequently, primarily based on the needs analysis that has been performed and the facts inside the area, it's miles essential to expand a take a look at to assessing college students' digital literacy abilities. The check advanced is within the shape of a multiple desire closed-ended check with 4 answer picks. This test targets junior high school students in grades 7 to 9. The aspects and indicators used in the preparation of this test refer to digital literacy aspects from several experts, namely internet searches, hypertext guides, evaluation of content and information, and compilation of knowledge (Bawden, 2008; Eshet-Alkali & Amichai-Hamburger, 2004; Gilster, 1997; Cassie Hague & Payton, 2013). Digital literacy aspects and an explanation of each item's questions can be seen in Table 2. Meanwhile, examples of development results can be seen in Figure 1.

Content Validation by Experts

The results of content validation carried out by experts can be seen in Table 3. In Table 3, it can be seen that five items have a value of less than 1. Item 3 has an aiken v value of 0.88; item 4 has a value of 0.75; items 9, 10, and 13 have a value of 0.88. These five items have a value of less than 1, so they are not sufficient for the rules of Aikens V (Aiken, 1985). Due to inadequate, these five items need to be revised. The validators provided suggestions and comments for improvement, namely in written item questions and the relevance of animations in questions related to aspects.

Reliability test using the Rasch Model

After going through the validation stage by expert lecturers, the digital literacy ability test instrument is then carried out in empirical or reliability trials. Empirical check analysis or evaluation of the Rasch version became done using the QUEST program. The ability of digital literacy tested as many as eight closed-ended multiple choices. The results of the Rasch model analysis using Quest are described in Figure 2 is a map of items and persons, Figure 3 shows the items' distribution based on their fit with the Rasch model, Figure 4 of item difficulty level, and Table 4.

Figure 2 is a map of objects and individuals. The right side is the object quantity, while the left is the respondents' distribution, wherein each pass represents 127 respondents. The distribution of objects and respondents is arranged at the identical scale in order that, in fashionable, the items have a better degree of difficulty than the respondents' capacity. Object range 3 is the maximum difficult object.

Figure 3 shows the items' distribution based on their fit with the Rasch model. Content validity uses the Rasch model to determine whether an item's score is significant, meaningful, useful, and purposeful (Mohamad et al., 2015). Whether an item is valid or not can also be determined if the MNSQ Infit value = 0.77-1.30 (Adams & Kho, 1996) and outfit (-2.0 to +2.0) (T. Bond, 2015). The vertical dotted line indicates the range of accepted INFIT MNSQ values. Figure 3 shows seven questions are at the acceptance limit, while 1 question, item 1, is outside the acceptance limit. The acceptance limit for the Rasch model is that the INFIT MNSQ is between 0.77 – 1.33 and the OUTFIT t ≤ 2, so the seven questions follow the Rasch model (Rostina, 2016). Item 1 is outside the acceptance limit, so that item does not fit the Rasch model. This item should be revised or discarded.

Figure four indicates that object 1, out of 127 respondents who spoke back, 116 replied effectively. While the wide variety -2.90 represents the difficulty degree of item (b). The higher the score, the extra hard the hassle. A fee towards -2 manner the object is simply too clean, and vice versa; closer to 2 means the object is too hard. INFIT and OUTFIT values are used to check the accuracy of gadgets with the Rasch model. The quest determines that an object will healthy the model if the INFIT MNSQ cost ranges from zero.77 to one.33 (Adam & S.T., 1996). Some use checks primarily based on the INFIT t fee, specifically, the range between -2 and +2 (T. G. Bond & Fox, 2015).

Item quantity has a fee of 0.85 with a high degree of problem. Object range three has a price of 1.92, that is rather difficult. Item range four has a price of -1.08 which has a low problem level. Item range 5 has a fee of 0.eighty one which has a excessive issue degree. Object range 6 has a fee of 0.43 which has a medium difficulty stage. Object number 7 has a price of 0.forty three which has a medium issue degree. Object wide variety eight has a fee of zero.06 which has a medium problem level.

Table 4 describes the match and misfit gadgets. The manner to discover in shape and misfit items is to compare the INFIT MNSQ price with the sum of the imply and general deviation values. The results of the Quest analysis obtained that the average value Infit MNSQ was 1.01 with a standard deviation of 0.15, and the average value of the Outfit Mean Square was 1.05 with a standard deviation of 0.41. The Infit Mean Square value is 1.01 ± 0.15 or 1.01- 0.15 = 0.86 to 1.01 + 0.15 = 1.16 while the Outfit Mean Square value is 1.05 ± 0.41 or 1.05 - 0.41 = 0.64 to 1.05 + 0.41 = 1.46. The results show that the value of INFIT Mean of INFIT t is -0.08 with a standard deviation of 0.98, and the value of OUTFIT Mean of OUTFIT t is -0.08 with a standard deviation of 0.88. The INTFIT Mean of INFIT t value is -0.08 ± 0.98 or -0.08 -0.98 = -1.06 to -0.08 + 0.98 = 0.9 while the OUTFIT Mean of INFIT t value is -0.08 ± 0.88 or -0.08 – 0.88 = -0.96 to -0.08 + 0.88 = 0.8.

The reliability value indicates that 0.97 belongs to the reliable category and is very high for tests used in learning (Budiastuti & Bandur, 2018). This value indicates that the test instrument developed is a valid test. Consequently, the seven virtual literacy talents questions advanced observe the Rasch model and may be used. This is based at the outcomes of the analysis received. The suggest square infit is within the variety 0.86 -1.16, and the value of outfit t ≤ 2, so usual, seven questions are underneath the Rasch model and can be used to assessing virtual literacy abilties.

The results showed that the development of this multiple-choice closed-ended test instrument succeeded in producing a assessingment tool that could comprehensively assessing students' digital literacy skills. The test instrument has high-quality content validity after going through the stages of expert review and validation. Analysis of the test instrument shows that the test instrument has strong validity in measuring students' digital literacy skills. In addition, instrument reliability testing is carried out to ensure the consistency of assessingment results. In this case, this test instrument shows a high level of reliability, indicating that this instrument can be used for evaluation.

Educational institutions can use this effective multiple-choice closed-ended test instrument to assessing and understand students' digital literacy levels. Assessingment results can provide insight to teachers in designing more effective learning approaches. In addition, this instrument can also assist educational institutions in creating digital literacy programs that suit the needs of students.

An effective digital literacy test tool must assessing various essential aspects of digital literacy skills. The closed-ended test format with multiple choice was chosen because it can provide advantages in objectively measuring digital literacy skills, assessing knowledge and understanding, and assessing applications. It is easy to manage and can be used for various samples in a limited time (AA et al., 2005; Rodriguez, 2015). Closed-ended multiple-choice tests allow examiners to evaluate students' understanding and knowledge more efficiently (Semyonov-Tal & Lewin-Epstein, 2021).

This research relates to the field of open and distance learning. The digital literacy test developed can be used to evaluate students' digital literacy skills in open and distance learning environments. This research can help identify the extent to which students can adapt and participate in the online learning environment. The results of digital literacy tests can provide insight into students' digital literacy abilities. This information can be used to develop and adapt curricula and learning materials to better suit students' digital literacy needs in open and distance learning contexts. The research results guide developing more effective digital learning materials aligned with students' digital literacy needs. This test can help identify aspects that need improvement in digital skills, such as online navigation, information evaluation, and virtual collaboration. Valid and feasible tests can be an effective monitoring tool to measure students' digital literacy progress during the distance learning period. Data from these tests can be used to provide ongoing feedback to students and teachers regarding their digital literacy progress. Implementing digital literacy tests can help improve the quality of online learning by ensuring that students have the skills necessary to succeed in a digital learning environment. Thus, this research can significantly contribute to understanding and improving students'

digital literacy in the context of open and distance learning, which is increasingly important in this digital era. According to experts, there are many aspects of digital literacy skills. For further research can develop tests on other aspects. The number of samples used can be expanded on a large scale to get more accurate results.

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K-12 TEACHERS' PERCEIVED EXPERIENCES WITH DISTANCE EDUCATION DURING THE COVID-19 PANDEMIC: A META-SYNTHESIS STUDY

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ABSTRACT

A sudden shift to distance education during the COVID-19 pandemic in Turkiye strained teaching and learning activities, placing K-12 teachers in a novel context with challenges and opportunities to investigate. This study explores the teaching experiences and opinions of K-12 teachers during the COVID-19 pandemic, focusing on challenges, advantages, and suggestions. Search queries were executed in leading databases (DergiPark, ULAKBIM TRDizin) to locate potential studies. Twenty-two studies meeting the predetermined inclusion and exclusion criteria were subjected to a rigorous and iterative thematic analysis using the qualitative meta-synthesis approach. The results revealed significant challenges categorized into ten themes: shortcomings in technology and infrastructure, student motivation and engagement, technology literacy, and social and emotional well-being. The results also highlighted key advantages of distance education in eight categories such as learning improvement, flexibility and convenience, and digital tools and resources. Additionally, the study identified valuable suggestions that contribute to the success of distance education, such as adapting curriculum, increasing access to technology, strengthening internet infrastructure, providing teacher training and support, developing engaging and interactive instructional materials, and improving communication and collaboration between students and teachers. The study results inform the development of evidence-based practices and policies that can support K–12 teachers in providing quality online education during times of crisis.

Keywords: COVID-19, distance education, challenges, benefits, K-12 teachers, meta-synthesis.

INTRODUCTION

Recent natural catastrophes in Turkiye, particularly earthquakes, have rendered schools inaccessible or unsafe, making distance education an alternative method of education delivery, as in COVID-19. It is well known that the COVID-19 epidemic has posed enormous problems for the world, impacting several facets of life, including education (Pokhrel & Chhetri, 2021). Worldwide, schools and universities have been forced to close temporarily, and governments have resorted to distance education to ensure the continuity of learning (Tadesse & Muluye, 2020). The need to keep students and teachers safe while allowing them to engage in academic activities forced the shift toward distance education (Papi, 2020). In this context, distance education refers to delivering instruction and learning through digital technologies that allow learners and teachers to be in different locations (Dede, 1990).

Numerous benefits of distance education have been demonstrated, including flexibility, convenience, cost-effectiveness, and scalability (Mupinga, 2005). Distance education can reach more students and allow them to learn at their own pace (Freire et al., 2021). Furthermore, distance education can provide chances for higher education and professional growth by granting students access to educational resources that are not available in their physical location (Kovalevsky et al., 2014). In a meta-analysis of 99 studies, Means et al. (2013) found that distance education can produce the same or more significant learning outcomes than traditional face-to-face instruction.

Despite its benefits, distance education presents teachers and students with several challenges, particularly in the context of the COVID-19 epidemic. Some challenges include a lack of access to technology and reliable Internet, isolation and social disconnection, and difficulty ensuring student engagement and motivation (Sari & Nayir, 2020). Teachers have also reported challenges in adapting to new teaching methods, the lack of training and support, and increased workload (Ferri et al., 2020).

Several potential solutions have been proposed to address these difficulties. These solutions include increasing access to technology and internet infrastructure, providing teacher training and support, developing more engaging and interactive instructional materials, and improving communication and collaboration between students and teachers (Kara et al., 2019). However, the effectiveness of these solutions in enhancing the experiences of K-12 teachers with distance education needs to be clarified, and there is a need for a more in-depth examination of the issue.

Despite the growing recognition of the significance of distance education as a means to ensure continuity of learning under challenging circumstances, there is a need for more reviews that examine its application and efficacy in post-disaster settings in Turkiye. While several studies have examined students' experiences with distance education, few have examined teachers' experiences (Stewart & Lowenthal, 2022). Furthermore, a more comprehensive and holistic approach is necessary to capture the experiences and needs of K-12 teachers directly involved in imparting education through distance modalities to obtain a deeper understanding of its implementation, challenges, and efficacy.

Consequently, the purpose of this study was to conduct a meta-synthesis of qualitative studies to explore the experiences of K–12 teachers with distance education during the COVID-19 pandemic. Specifically, this study aims to answer the following research questions:

1. What are the experiences of K–12 teachers regarding the significant challenges they face in distance education during the COVID-19 pandemic?
2. What are the benefits of distance education perceived by K–12 teachers during the COVID-19 pandemic?
3. What are the suggestions of K-12 teachers regarding improving distance education during the COVID-19 pandemic?

METHOD

This study used a meta-synthesis methodology to analyze and synthesize qualitative studies that explore K–12 teachers' experiences with distance education during the COVID-19 pandemic. Predetermined inclusion and exclusion criteria were followed to ensure a relevant and comprehensive sample.

The inclusion criteria for the study sample were qualitative or mixed-methods studies that discussed K–12 teachers' opinions on distance education during the COVID-19 pandemic, the challenges they faced during distance education, and the solutions they proposed. Exclusion criteria included studies that focused on the experiences of a different audience than K–12 teachers or were conducted before the pandemic. The inclusion and exclusion criteria used to select the studies are presented in Table 1.

Table 1. Inclusion/exclusion criteria

Criteria	Inclusion	Exclusion
Study Type	Qualitative or mixed-method studies	Other study types (e.g., quantitative studies)
Participant Focus	K–12 teachers	Studies focusing on other audiences
Topic Focus	Discussions on K–12 teachers' opinions, challenges, and solutions in distance education during the COVID-19 pandemic	Studies unrelated to K–12 teachers or conducted before the pandemic

Two leading platforms for scholarly publications in Turkiye, DergiPark, and ULAKBIM TRDizin databases, were used for conducting a comprehensive search to identify relevant studies. The search query meticulously detailed in Table 2 was employed for this purpose.

Table 2. Research Corpus and Search Queries for Inclusion Criteria

Research Corpus	
Database	DergiPark, ULAKBIM TRDizin
Period	No limit
Search Queries	
Subject-specific queries	KEYWORDS ("teachers" OR "educators" OR "instructors" OR "teaching professionals" OR "pedagogues" OR "faculty members" OR "academic staff" OR "teaching staff" OR "educational practitioners" OR "instructional specialists")
Field-specific queries	KEYWORDS ("distance education" OR "distance learning" OR "distance teaching" OR "online education" OR "online learning" OR "online teaching" OR "remote education" OR "remote learning" OR "remote teaching")
Context-specific queries	KEYWORDS ("elementary" OR "primary" OR "secondary" OR "school" OR "classroom" OR "K-12" OR "K12")
Boolean search parameter	AND

These databases were selected because they are considered the most comprehensive and reliable sources of Turkish-language research articles in education. In addition, the Google Scholar database was also utilized as an additional source of information. By employing multiple databases, the aim was to ensure the comprehensiveness of the search and increase the likelihood of identifying all relevant studies in the Turkish language. The initial search yielded 212 articles of which 168 unique articles were placed after removing duplicates. These articles were then screened based on their abstracts, resulting in the selection of 41 relevant articles. Subsequently, a full-text review was conducted, including 22 studies that met the criteria. A summary of these articles can be found in Table 3 below. Throughout these processes, two researchers coordinated the efforts. The inter-rater reliability of the selection process was assessed using Cohen's Kappa coefficient (κ), revealing substantial agreement between the two reviewers ($\kappa = 0.75$).

Table 3. Summary of the Articles Examined in the Study

Article ID	Reference	Methodology	Purpose	Participants	Sampling	Data Collection
1	(Gullu et al., 2022)	Mixed Method Research	Identify and provide solutions to problems faced by teachers during the COVID-19 period in distance education.	201 Teachers	Simple Random Sampling and Convenience Sampling	Survey and Semi-Structured Interviews
2	(Taskin & Aksoy, 2021)	Mixed Method Research (Parallel Design)	Objectively reveal teachers' opinions and expectations regarding distance education.	292 Teachers	Purposive Sampling and Maximum Variation Sampling	Survey and Semi-Structured Interviews
3	(Sertkaya Dinler & Dundar, 2019)	Qualitative Phenomenological Study	Highlight the problems experienced by classroom teachers during the pandemic.	40 Classroom Teachers	Convenience Sampling	Semi-Structured Online Interviews
4	(Sahin & Aykac, 2022)	Qualitative Study	Evaluate the perspectives of secondary school foreign language teachers on the implementation of distance education and the challenges encountered.	14 Foreign Language Teachers	Convenience Sampling	Semi-Structured Interviews
5	(Askan & Usta, 2022)	Qualitative Study	Investigate the challenges, effectiveness, and perspectives of information technology teachers affiliated with the Ministry of National Education concerning distance education.	21 ICT Teachers	Criterion Sampling	Semi-Structured Interviews
6	(Alper, 2020)	Qualitative Explanatory Case Study	Examine the transition processes to distance education in K-12 schools without prior experience.	71 Teachers	Convenience Sampling	Semi-Structured Interviews, Observations, Field Notes
7	(Tunca & Bay, 2022)	Qualitative Study	Uncover preschool teachers' views on distance education in the context of the Covid-19 outbreak.	17 Preschool Teachers	Convenience Sampling and Criterion Sampling	Semi-Structured Interviews
8	(Demir & ozdas, 2020)	Qualitative Case Study	Investigate the opinions of primary school teachers regarding distance education activities during the COVID-19 period.	44 Classroom Teachers	Typical Case Sampling	Surveying Open-Ended Questions
9	(Aral & Kadan, 2021)	Qualitative Phenomenological Study	Identify the problems encountered by preschool teachers in their distance education practices during the COVID-19 pandemic.	24 Preschool Teachers	Purposeful Sampling	Semi-Structured Interviews
10	(Shaikh & Ozdas, 2022)	Qualitative Phenomenological Study	Evaluate English teachers' perspectives on distance education, considering the Covid-19 pandemic, and provide recommendations.	24 English Teachers	Convenience Sampling	Semi-Structured Interviews
11	(Yazici et al., 2022)	Qualitative Phenomenological Study	Examine preschool teachers' views on distance education during the COVID-19 pandemic.	28 Preschool Teachers	Purposeful Sampling	Semi-Structured Interviews
12	(Usta & Donmez, 2021)	Qualitative Phenomenological Study	Learn elementary school teachers' opinions on COVID-19 educational activities.	20 Classroom Teachers	Convenience Sampling	Semi-Structured Interviews
13	(Altin & Gundogdu, 2021)	Qualitative Case Study	Investigate remote education practices in early childhood education based on preschool teachers' views.	21 Preschool Teachers	Convenience Sampling	Semi-Structured Interviews
14	(Yolcu & Kurt, 2021)	Sequential Explanatory Mixed Method Research	Identify problems EBA-positive teachers face using the EBA live lesson application during COVID-19.	96 Teachers	Convenience Sampling and Purposeful Sampling	EBA Attitude Scale and Semi-Structured Interviews

15	(Bakirci et al., 2021)	Qualitative Case Study	Determine middle school teachers' opinions on distance education.	12 Teachers	Convenience Sampling	Semi-Structured Interviews
16	(Mutluer & Celikoz, 2022)	Sequential Exploratory Mixed Method Research	Understand teachers' views on distance education in Turkiye during the pandemic and assess generalizability.	729 Classroom Teachers	Convenience Sampling and Purposeful Sampling	Semi-Structured Interviews
17	(Cetinkaya & Elalmis, 2022)	Qualitative Case Study	Reveal teachers' opinions on initial reading and writing instruction during distance education.	5 Classroom Teachers	Purposive Sampling with Random Selection	Semi-Structured Focus Group Interviews
18	(Dere & Akkaya, 2022)	Qualitative Phenomenological Study	Evaluate remote social studies lessons based on teachers' experiences.	14 Social Science Teachers	Maximum Variation Sampling	Semi-Structured Interviews
19	(Gozde & Gulsen, 2021)	Qualitative Case Study	Assess the impact of the Covid-19 pandemic on education from teachers' perspective.	25 Teachers	Criterion Sampling	Surveying Open-Ended Questions
20	(Yapar et al., 2022)	Qualitative Phenomenological Study	Gather teachers' views on online distance education experiences through the EBA platform during COVID-19.	16 Teachers	Convenience Sampling	Surveying Open-Ended Questions
21	(Yilmaz & Aydogdu, 2022)	Qualitative Phenomenological Study	Investigate science teachers' opinions and experiences with online lessons during the COVID-19 pandemic.	15 Science Teachers	Maximum Variation Sampling	Semi-Structured Phone Interviews
22	(Erol & Akkus, 2022)	Qualitative Phenomenological Study	Examine problems experienced by teachers in distance education.	12 Teachers	Convenience Sampling	Semi-Structured Interviews

Thematic analysis was employed using MAXQDA 2022 (VERBI Software, 2021) to analyze the data from the selected studies and identify common themes and patterns related to K–12 teachers' experiences with distance education during the COVID-19 pandemic. This analysis identified the challenges and benefits of distance education and the best practices and recommendations offered by K–12 teachers. Thematic analysis was conducted by two independent researchers who reached a consensus on the final themes and sub-themes. Cohen's Kappa coefficient (κ) was calculated to assess inter-rater reliability, and a high level of agreement was found ($\kappa = 0.81$).

This study implemented specific procedures to ensure a comprehensive quality assessment of the selected studies. These procedures included establishing clear criteria for assessment, evaluating methodological rigor, assessing the credibility of findings, documenting the process transparently, and involving multiple reviewers to achieve consensus and reliability. By following these procedures, the study enhanced the trustworthiness and rigor of the quality assessment, thereby strengthening the reliability and validity of the synthesized findings.

Overall, several procedures were followed to ensure the trustworthiness of the study itself. First, the inclusion and exclusion criteria were predetermined and clearly stated. Second, the search process was documented to ensure transparency and reproducibility. Third, two reviewers independently carried out the screening process and Cohen's Kappa coefficient (κ) was calculated to assess inter-rater reliability. Fourth, the selected studies were subjected to rigorous quality assessment to ensure their validity and reliability. Finally, the data synthesis process was carried out by multiple researchers and Cohen's Kappa coefficient (κ) was calculated to assess inter-rater reliability.

In summary, this meta-synthesis study explored K–12 teachers' experiences with distance education during the COVID-19 pandemic. The study followed predetermined inclusion and exclusion criteria and employed a meta-synthesis methodology. Thematic analysis was used to synthesize the data and the study followed several procedures to ensure its trustworthiness, including calculating Cohen's Kappa coefficient (κ) to assess inter-rater reliability. The study contributed to evidence-based practices and policies that can support K–12 teachers in providing quality online education during times of crisis.

FINDINGS

In the results section, the outcomes of the study on distance education are presented, with a comprehensive analysis under various subheadings. First, the positive aspects of distance education are discussed, highlighting its potential to enhance accessibility and flexibility in learning. Subsequently, the various challenges encountered during the implementation of distance education are examined, encompassing technological issues, student engagement, and the importance of effective instructional design. Furthermore, recommendations are provided to address these challenges and improve the overall effectiveness of distance education.

Benefits

The current study showed that the benefits of distance education fall into eight themes: (1) learning improvements/support; (2) flexibility and convenience; (3) digital tools and resources; (4) student engagement and self-motivation; (5) accessibility and inclusivity; (6) classroom management; (7) sustainability and continuity; and (8) parental involvement. As shown in Table 4, each of these themes has several corresponding subthemes, which are described and reported below more comprehensively.

Table 4. Benefits of Distance Education

Theme/Subtheme	Article	n
LEARNING IMPROVEMENTS/SUPPORT		14
Allows individual learning	2, 10, 15, 19	4
Strengthens the communication between teachers and students	6, 10, 15	3
Appeals to different sense organs	2, 15	2
Increases the form and variety of learning	2, 6	2
Makes learning more efficient	8, 19	2
Enables students to increase their digital literacy skills	18	1
FLEXIBILITY AND CONVENIENCE		13
Eliminates the space and time problem	2, 6, 11, 15, 18, 19	6
Provides a comfortable learning environment	6, 10, 11	3
It reduces distracting external factors	4, 6, 10	3
Offers flexible working opportunities	10	1
DIGITAL TOOLS AND RESOURCES		9
Allows various educational materials and tools	4, 6, 11, 17, 18, 21	6
Allows teachers to use technology more actively in their lessons	6, 17, 21	3
Allows teachers to discover new tools for teaching and learning	11, 21	2
STUDENT ENGAGEMENT AND SELF-MOTIVATION		9
Increases students' interests and motivation	8, 10, 11, 21	4
Enables students to focus more easily	4, 6, 10	3
Enables students to have self-discipline	11	1
Increases students' participation in the lesson	7	1
ACCESSIBILITY AND INCLUSIVITY		9
Allows the course to be recorded and accessed repeatedly	6, 7, 18	3
Provides the opportunity to reach many students at the same time	15, 18	2
Provides fast access to information	2, 15	2

Provides convenience to disadvantaged students	18	1
Provides access to resources from a single point	2	1
CLASSROOM MANAGEMENT		8
Allows teachers to use class time more effectively	2, 5, 6, 11, 15, 19, 21	7
Enables teachers to improve classroom management	21	1
SUSTAINABILITY AND CONTINUITY		8
Ensures the reuse of educational resources	2, 6, 7, 18	4
Reduces the cost of education	2, 11	2
Allows the continuation of education in crises	18, 19	2
PARENTAL INVOLVEMENT		3
Enables families to be involved more in education processes	16, 19	2
Allows parents to spend more time with their children	16	1

Learning improvements and support: Distance education made it feasible for students to learn at their own speed and meet their specific learning needs (n = 4). It also strengthened communication between teachers and students, allowing for increased interaction and feedback (n = 3). Moreover, the integration of distance education appealed to different senses, providing learners with diverse learning modes (n = 2). Additionally, distance education increased the form and variety of learning, providing access to various educational materials and resources (n = 2). Distance education also made learning more efficient (n = 2), achieved through technology and other digital tools, which streamlined the learning process and made it more accessible to students. Finally, distance education enabled students to increase their digital literacy skills, allowing them to develop and enhance their technological competencies (n = 1).

Flexibility and convenience: Distance education eliminated space and time constraints, allowing students to access educational materials and participate in classes from any location and at any time (n = 6). It also provided a comfortable learning environment, enabling learners to study in a familiar and calm setting that suited their preferences (n = 3) and minimized external variables such as noise and interruptions that could impede learning (n = 3). Besides, distance education enabled learners to study at their own pace and on their own timetable, making it simpler to balance educational pursuits with personal or professional obligations (n = 1).

Digital tools and resources: Distance education allowed for a variety of educational materials and tools to be utilized, providing students with access to various resources (n = 6). This use of technology also allowed teachers to incorporate technology into their lessons actively, making the learning process more engaging and interactive (n = 3). Additionally, integrating digital tools and resources enabled teachers to discover new tools for teaching and learning, increasing their technological competencies and skills (n = 2).

Student engagement and self-motivation: Distance education increased students' interest and motivation, making learning more pleasant and efficient (n = 4). In addition, using digital tools and resources in distance education facilitated students' ability to concentrate and cultivate self-discipline (n = 4). Furthermore, distance education increased student participation in the lesson, as motivated students are more likely to engage in class discussions and activities (n = 1).

Accessibility and inclusivity: Distance education allowed courses to be recorded and accessed multiple times, allowing students to review course material at their own pace (n = 3). It also made it possible to reach lots of students simultaneously, regardless of their location, thereby expanding access to education (n = 1). In addition, using digital devices enabled quick access to information, leading to more efficient and effective learning (n = 1). Additionally, the convenience of distance education made it more accessible to disadvantaged students, providing them with equal educational opportunities (n = 1). In addition, distance education enabled access to diverse resources from a single location, consequently decreasing learning barriers

and increasing inclusivity (n = 1).

Classroom management: Distance education allowed teachers to use class time more effectively, as technology facilitated the management of class activities and the organization of content delivery (n = 7). Moreover, integrating digital tools and resources gave teachers a better understanding of classroom management techniques and practices, allowing them to manage their virtual classrooms (n = 1) more effectively.

Sustainability and continuity: Integrating digital tools and resources in distance education ensured the reuse of educational resources, thereby reducing waste and promoting sustainability (n = 4). In addition, distance education reduces the cost of education by minimizing the need for physical infrastructure and travel expenses, making education more accessible and affordable (n = 2). Finally, distance education allowed for continuing education in crises, such as natural disasters or pandemics, ensuring that students could continue their studies uninterrupted (n = 2).

Parental involvement: Distance education allowed for increased family involvement in the education process, providing them with more significant opportunities to participate in their children's learning experiences (n = 2). Moreover, the flexibility of distance education motivated parents to spend more quality time with their children, as they can monitor their children's learning progress and provide additional support as needed (n = 1).

Challenges

The current review study identified significant challenges in distance education and grouped them into ten meaningful themes. Each theme is accompanied by several relevant subthemes, as shown in Table 5.

Table 5. Challenges of Distance Education

Theme/Subtheme	Article	n
TECHNOLOGY AND INFRASTRUCTURE		61
Limited access to technology such as the Internet, software, and hardware	1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22	19
Inadequate internet connectivity	1, 2, 3, 4, 5, 7, 8, 10, 11, 15, 16, 18, 19, 20, 21, 22	16
Technical difficulties and glitches	2, 4, 5, 8, 9, 10, 11, 16, 20, 21	10
LMS-related issues such as language support and effectiveness	1, 2, 3, 4, 8, 10, 11, 15, 18, 19, 20	11
The lack of technical support	1, 2, 4, 10, 11	5
STUDENT MOTIVATION AND ENGAGEMENT		47
Difficulty keeping students engaged	1, 2, 3, 4, 5, 6, 8, 9, 10, 13, 14, 15, 16, 18, 19, 20, 22	17
Difficulty keeping students motivated	1, 2, 3, 4, 5, 6, 8, 9, 10, 13, 14, 18, 19, 22	14
Distraction and lack of focus in students	2, 3, 7, 8, 10, 13, 14, 22	8
The low attendance of students in classes, especially in rural areas	15, 18, 21, 22	4
Students' lack of interest	15, 16, 19, 20	4
TECHNOLOGY LITERACY		30
Teachers' and students' lack of technology literacy skills	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 18, 19, 20	14
The limited prior knowledge of distance education	3, 4, 5, 6, 7, 8, 10, 19	8
Challenges in adapting to distance education	3, 4, 5, 6, 7, 8, 10, 19	8
SOCIAL AND EMOTIONAL WELL-BEING		30
Physical health problems	1, 2, 3, 6, 10, 11, 14, 15, 16, 22	10
Isolation and psychological problems	1, 2, 3, 6, 10, 11, 14, 15, 16, 22	10
Technological addiction in students	3, 7, 8, 11, 15, 22	6
Privacy violation	1, 2, 4, 18	4

CLASSROOM MANAGEMENT		25
Inadequate home environment	4, 5, 8, 10, 11, 15, 18	7
Increased workload for teachers	2, 6, 8, 10, 11, 19	6
Challenges with maintaining discipline	2, 3, 6, 10, 19, 21	6
Challenges with managing student behaviors	2, 3, 6, 21	4
Time-consuming	8, 22	2
LEARNING CHALLENGES		21
Lack of teacher and peer support	2, 3, 5, 6, 10, 11, 16, 19, 21, 22	10
Challenges in achieving implicit learning	1, 3, 5, 8, 10, 11, 15	7
Challenges in understanding the subject matter	15, 18, 19, 22	4
SOCIAL INTERACTION AND COLLABORATION		21
Limited communication and social interaction	1, 2, 3, 5, 6, 7, 10, 11, 15, 16, 17, 18, 19, 21, 22	15
Limited collaboration	5, 7, 10	3
Difficulty building relationships	2, 5, 10	3
ASSESSMENT AND EVALUATION		17
Difficulty conducting assessment and evaluation	1, 4, 8, 9, 10, 11, 18	7
Challenges in measuring and evaluating students' progress	14, 16, 18, 22	4
Concerns about cheating and academic integrity in assessments	2, 4, 10	3
Inadequate assessment and evaluation tools	10, 16, 18	3
ADMINISTRATIVE AND POLICY ISSUES		16
Insufficient class time	15, 18, 20, 21, 22	5
Limited educational recourses	3, 4, 12, 14	4
Unsuitable courses for distance education	2, 4, 5, 21	4
Challenges with online instructional design	10, 15, 22	3
PARENTAL INVOLVEMENT AND SUPPORT		17
Challenges with parental engagement	3, 8, 9, 13, 14, 15, 16, 17, 18, 22	10
Parents' lack of knowledge of technology use	14, 16, 17, 20	4
Communication challenges with parents	18, 19, 22	3

Technology and infrastructure: Limited access to technology was widely reported (n = 19), indicating that some students and teachers did not have the necessary hardware, software, or equipment to participate in online classes effectively. Inadequate internet connectivity was another major issue (n = 16), with several studies highlighting the impact of slow or unstable Internet on teaching and learning. Multiple studies (n = 10) reported technical difficulties and glitches, including software malfunctions, system errors, and connection problems. In addition, several studies (n = 11) underlined LMS-related issues such as language support and effectiveness, indicating that some platforms and tools used in distance education may not meet the needs of all users. The lack of technical support was also highlighted (n = 5), with some studies reporting that students and teachers did not receive sufficient assistance when facing technical problems.

Student motivation and engagement: Many studies (n = 17) reported difficulties keeping students engaged and motivated, with various factors contributing to this challenge, such as the absence of face-to-face interaction, lack of social support, and limited interaction with peers and teachers. Distraction and lack of focus in students were also reported (n = 8), with studies indicating that students may face various

distractions and barriers, such as competing priorities, limited resources, and difficulty in managing time. Besides, several studies (n = 4) reported low attendance of students in classes, particularly in rural areas, indicating a lack of interest or difficulties in accessing distance education opportunities. Students' lack of interest was highlighted in a few studies (n = 4), indicating a need to design engaging and meaningful activities that promote students' interest and motivation in distance education.

Assessment and evaluation: Several studies (n = 7) reported difficulties adapting traditional methods of evaluation to the online environment. Measuring and evaluating students' progress was also underlined (n = 4), indicating that some assessment methods may not be suitable for assessing online learning outcomes. Additionally, few studies (n = 3) reported teachers' concerns about cheating and academic integrity in assessments, underscoring the challenge of ensuring academic integrity while monitoring students in a virtual environment. Some studies (n = 3) pointed to inadequate assessment and evaluation tools, indicating a need for further development of tools and strategies for assessment and evaluation in distance education.

Social interaction and collaboration: Limited communication and social interaction were widely reported (n = 15), with several studies indicating that distance education may hinder students' ability to interact with their peers and teachers. In addition, some studies (n = 3) identified limited collaboration as a significant challenge (n = 3), reporting that distance education may limit students' opportunities to collaborate on group projects or complete assignments jointly. Moreover, few studies (n = 3) reported difficulties in establishing relationships in the online environment, indicating that the absence of face-to-face interaction and nonverbal signals make it more difficult for students to develop relationships with their peers and teachers.

Social and emotional well-being: Many studies (n = 10) reported that extended periods of inactivity and prolonged exposure to screens have led to physical health issues such as head, neck, and back pain. This is a particular concern for students and teachers who attend classes online for long periods of time (e.g., several hours a day). Isolation and psychological problems, including anxiety, stress, emotional deprivation, increased isolation and loneliness, mental exhaustion, and burnout, were also identified as significant concerns (n = 10). Additionally, some studies identified technological addiction in students as a challenge (n = 6). With the increasing use of technology in distance education, some students may develop dependence or addiction to their devices. Finally, a few studies (n = 4) underlined the challenges due to privacy violations because distance education can threaten teachers' and students' privacy, particularly if they are required to use their personal devices or share personal information online.

Learning in distance education: Numerous studies (n = 10) marked an absence of assistance from teachers and peers, highlighting the difficulties in delivering tailored support and feedback to students in remote settings. Moreover, some studies (n = 7) reported difficulty obtaining implicit learning, highlighting the hurdles students encounter while acquiring tacit knowledge and abilities through experience and practice, particularly in distant or online learning environments. In addition, a relatively small number of studies (n = 4) reported the difficulties students encounter in learning and digesting new knowledge, particularly in complicated or technical subject areas.

Technology literacy in distance education: Teachers' and students' lack of technology literacy skills were frequently reported (n = 13), with difficulties ranging from basic computer skills to advanced technical knowledge. Limited prior understanding of distance education was also reported in multiple studies (n = 8), indicating that some teachers and students were unfamiliar with the tools, platforms, and pedagogies used in distance education. Additionally, several studies (n = 8) underscored the difficulties of adapting to distance education, highlighting the transition from the traditional face-to-face instruction to online teaching and learning.

Administrative and policy issues: Insufficient class time was reported in multiple studies (n = 5), with concerns about limited time available for instruction and interaction with students. Several studies (n = 4) drew attention to limited educational resources, underlining the issues related to the availability and quality of online educational materials. Moreover, unsuitable courses for distance education were highlighted in multiple studies (n = 4), particularly in subjects that require hands-on experimentation and application. Moreover, three studies highlighted problems with designing online instruction, such as creating engaging and interactive student learning experiences.

Parental involvement and support: Many studies (n = 10) reported challenges with parental engagement, highlighting a lack of necessary attention and involvement from parents, and others noted instances of parents interfering in the class. Parents' lack of knowledge of technology use was also reported in multiple studies (n = 4), indicating that some parents may struggle to navigate the platforms and tools used in distance education. Three studies underlined the challenges of communicating with parents and highlighted difficulties in establishing effective lines of communication between teachers and parents in the online environment.

Classroom management: An inadequate home environment was identified as a challenge in multiple studies (n = 7), including noise, crowded families, and a lack of privacy. The challenges of maintaining discipline were also highlighted (n = 6), with several studies reporting difficulties ensuring student adherence to rules and expectations. Besides, several studies (n = 6) highlighted the increased workload for teachers, with problems ranging from managing multiple online platforms to providing individualized feedback. In addition, a few studies (n = 4) raised the challenge of managing student behaviors, with difficulties ranging from distractions to non-participation and disruptive behaviors. In two studies, distance education was considered time-consuming due to the difficulties encountered, such as additional preparation time and grading.

Suggestions

Regarding the suggestions provided in the reviewed studies, seven themes have emerged as crucial for ensuring quality and effective distance education. Table 6 shows the themes and associated sub-themes, presented and reported in detail below.

Table 6. Suggestions for Distance Education

Theme/Subtheme	Article	n
CONTENT AND CURRICULUM		28
The diversity of online educational materials should be increased.	1, 7, 8, 9, 11, 12, 13, 20, 21	9
The educational content should be adapted to be suitable for distance education.	1, 7, 8, 10, 15	5
The educational goals and objectives should be adapted for distance education.	1, 7, 8, 10, 15	5
The number and hours of classes should be arranged in a way suitable for distance education.	1, 7, 9, 21	4
The quantity and quality of online assessment and evaluation tools should be increased.	1, 14, 15	3
The materials and activities should be adapted to be suitable for distance education.	14, 15	2
TECHNOLOGY AND INFRASTRUCTURE		23
Access problems to the Internet, hardware, and other technological tools should be addressed.	1, 2, 5, 7, 8, 10, 11, 12, 13, 14, 16, 18, 19, 20	14
Infrastructure-related issues should be addressed.	1, 8, 10, 15, 16, 17, 19	7
Real-time technical support services should be provided.	1, 15	2
PROFESSIONAL DEVELOPMENT FOR TEACHERS		17
In-service training on distance education should be provided to teachers.	1, 2, 4, 5, 8, 9, 10, 11, 13, 19, 20, 21	12
In-service training on digital literacy and media literacy should be provided to teachers.	12, 13, 17, 18, 19	5
LEARNING MANAGEMENT SYSTEM		12
The capacity of distance education platforms should be strengthened for stability.	1, 3, 5, 7, 8, 10, 11, 14, 19	9
Distance education platforms should allow for the recording of synchronous classes.	14	1
Distance education platforms should provide asynchronous access options.	14	1
Distance education platforms should provide language support.	19	1

PARENT AND COMMUNITY INVOLVEMENT		10
Collaboration should be established with parents.	1, 6, 7, 13	4
More involvement of parents in the distance education processes should be ensured.	3, 18, 19	3
Collaboration between internal and external stakeholders should be facilitated in distance education.	15, 19	2
The communication between parents, students, and teachers should be strengthened.	15	1
POLICIES AND PRACTICES		11
Equal opportunities should be provided in education.	8, 10, 15, 21	4
A sustainable hybrid education system should be implemented.	18, 19, 21	3
Attendance to classes should be mandatory.	1, 13	2
Turning on the camera should be mandatory.	1	1
Policies suitable for distance education should be developed.	19	1
TRAINING AND GUIDANCE FOR STUDENTS AND PARENTS		11
In-service training on distance education should be provided to parents.	3, 13, 15, 16, 18, 20	6
In-service training on digital literacy and media literacy should be provided to students.	19, 20	2
In-service training on distance education should be provided to students.	19, 20	2
Guidance activities for students should be organized.	14	1

Content and curriculum: The reviewed studies advised enhancing the diversity of easily accessible online educational resources to meet students' diverse learning needs and boost engagement (n = 9). Additionally, the educational content in distance education should be adapted to be suitable for online learning environments (n = 5), and the number and hours of classes should be arranged in a way that is appropriate for online learning (n = 4). Educational goals and objectives should also be modified to suit online learning environments (n = 5). Furthermore, the quality and quantity of online assessment and evaluation tools should be improved to enhance the learning experience in online courses (n = 3). Finally, the materials and activities used in online courses should be adjusted to suit the online learning format (n = 2).

Technology and infrastructure: The reviewed studies have indicated that addressing access problems to the Internet, hardware, and other technological tools is critical in ensuring effective distance education (n = 14). In addition, infrastructure-related issues such as network reliability, system security, and online storage capacity should also be considered (n = 7). To support distance learners in their online courses, real-time technical support services should be provided to address any technical issues and provide assistance when necessary (n = 2).

Professional development of teachers: The reviewed studies have recommended providing in-service training for teachers to improve their skills and competencies in distance education (n = 12). Additionally, studies suggest that in-service training on digital literacy and media literacy should be offered to teachers to help them develop the necessary skills to use technology in teaching effectively (n = 5).

Learning management system: One of the most prominent suggestions is to strengthen the capacity of distance education platforms to ensure their stability and effectiveness (n = 9). Additionally, distance education platforms should allow for the recording of synchronous classes to facilitate student access to course content (n = 1). Moreover, distance education platforms should provide asynchronous access options to enable students to learn at their own pace and convenience (n = 1). Another important suggestion is to provide language support in distance education platforms to cater to the needs of non-native speakers (n = 1).

Parent and community involvement: The reviewed studies suggested that collaboration with parents should be established to meet students' learning needs (n = 4). Parents should be more involved in the distance education processes to support their children's education (n = 3). Furthermore, collaboration between internal and external stakeholders should be facilitated to improve the quality of distance education (n = 2). The communication channels between parents, students, and teachers should be strengthened to ensure effective communication (n = 1).

Policies and practices: The reviewed studies suggested that equal opportunities should be provided to ensure that all students have access to the necessary technology and resources to participate in online classes (n = 4). A sustainable hybrid education system that combines online and face-to-face instruction has also been suggested as a viable option (n = 3). Regarding attendance, some studies recommend making attendance in classes mandatory (n = 2), and others suggest making it mandatory for students to turn on their cameras during online classes (n = 1). Additionally, studies recommend developing policies suitable for distance education (n = 1).

Training and guidance for students: The reviewed studies recommended in-service training for parents on distance education to support students' learning in a remote environment (n = 6). Furthermore, digital literacy and media literacy skills training for students is necessary to promote their effective participation in online courses (n = 2). The studies also recommend offering students in-service training about distance education to facilitate their transition to online learning (n = 2). To assist students in navigating the challenges of remote learning, providing guidance activities is also recommended (n = 1).

DISCUSSIONS AND CONCLUSION

The discussion section covers the advantages and disadvantages of distance education under various subheadings. Initially, the benefits of distance education are discussed, with a focus on its potential to increase accessibility and flexibility in learning. Subsequently, the numerous obstacles that arise during the implementation of distance education are examined, including issues about technology, student engagement, and the need for an effective instructional design. Additionally, suggestions are provided for addressing these obstacles and enhancing the efficacy of distance education.

Benefits

Distance education is very often associated with challenges, but it can also enrich the teaching and learning process with its opportunities. The current review study revealed that distance education could be beneficial and productive in several ways, from encouraging improvement in student learning to providing a flexible and convenient learning environment, enabling the use of digital tools and various resources, boosting student motivation, providing access to recorded content, aiding teachers in time management, permitting content reuse, and engaging parents in learning activities. It should be noted that some of these benefits could be attributed to the features of technologies used to deliver educational content to students. For instance, immersive technologies such as virtual reality and augmented reality positively affect students' academic performance and motivation in distance education ((Turan & Karabey, 2023). Additionally, as demonstrated by Zafeer et al. (2023) and Rafiq et al. (2023), these findings are consistent with the theory that digital tools promote student engagement and learning outcomes.

The benefits reported in this review broadly support the work of other studies focusing on the white side of distance education for teachers and students during the pandemic. This study suggests that students in distance education are more likely to learn independently since they can work at their own pace and access and reuse course materials (Ratten, 2023; Wong, 2023). Moreover, distance education promotes accessibility and inclusiveness by removing geographical barriers and closing educational disparities (Iniesto et al., 2021). It also proves to be a sustainable and cost-effective educational approach by reducing the need for physical infrastructure and travel expenditures (Akindele et al., 2022; Garlinska et al., 2023). In addition, distance education demonstrates its resilience by enabling continuous learning during crises such as pandemics (Bozkurt et al., 2022).

This meta-synthesis analysis builds on and strengthens existing evidence, highlighting the potential for distance education to revolutionize education and guiding educators and policymakers in developing effective online learning environments. By recognizing the benefits of distance education in terms of adaptability, engagement, accessibility, cost-effectiveness and resiliency, stakeholders can make informed decisions regarding its incorporation into K–12 educational settings and the exploitation of its benefits. Continued research in this area is essential to refine best practices and assure the continued success and development of distance education.

Challenges and Suggestions

During and after large-scale natural disasters such as pandemics and earthquakes, all parties involved in massive distance education face numerous obstacles. Despite some studies reporting that teachers successfully carried out and adapted to the distance education process (Alper, 2020), this study identified a significant typology of obstacles faced by K–12 teachers in distance settings and compiled recommendations for mitigating their negative effects.

Our study confirms earlier findings (Elcicek, 2022; Kil & Usun, 2021) that the challenges posed by distance education involve students, teachers, administration, programs, infrastructure, and financing. Not only have the study findings further expanded our understanding of these challenges, but they have also highlighted a unique set of issues specific to the digital nature of the educational process.

The findings highlighted the need for improved access to technology, stable internet connections, and robust technical support to ensure effective distance education for teachers and students (Yeh & Tsai, 2022). With these challenges addressed properly, students from diverse backgrounds and teachers can have a more equitable educational environment (Anthony & Miller, 2022).

Technological literacy and pedagogical training are critical to the success of distance education (Johnson et al., 2023). However, this study showed that teachers and students lack it, hindering their adaptability to distance education technologies. Therefore, teachers (Jimoyiannis & Koukis, 2023), students, and parents should be trained on using technology effectively in distance education.

Keeping students motivated and engaged is essential for success (Yu, 2022), but it becomes a critical challenge in distance settings. A practical method could be to enrich teaching/learning activities with multimedia elements, engaging content, clear communication channels, group projects, online discussions, virtual study groups, ramified activities (Nieto-Escamez & Roldan-Tapia, 2021), virtual and augmented reality applications (Eldokhny & Drwish, 2021), individualized support, and timely feedback. In addition, the parental involvement is also essential in motivating and engaging students in distance education (Alharthi, 2023). Therefore, parents should be involved in students' learning activities and collaborate with teachers to help students improve their learning. Students who are very engaged with distance learning are likely to study more on their own outside the virtual classroom (Gherghel et al., 2023).

Distance education has threatened teachers' and students' social and emotional well-being by interrupting their school lives for long periods. Digital resources can help students communicate and socialize more, overcoming these limitations. Moreover, collaborative initiatives, especially teachers' partnerships with parents (Lanzl, 2023), can increase social connection and collaboration in distance education (Moles et al., 2023).

Along with the scarcity of class time and assessment tools, teachers also faced challenges in maintaining the fairness and validity of assessments (Yoruk, 2021). Teachers can use distance learning-friendly evaluation methods, such as project-based, peer-reviewed self-assessments, along with the available tools adapted to meet distance education needs.

Effective distance education implementation and administration are contingent on timely and appropriate policies. The findings revealed that administrative and policy responses to distance education challenges have been inadequate, leaving teachers with an excessive burden, little support, and limited educational resources that are unsuitable for distance education. Hybrid distance education is suggested as an alternative education method to mitigate the factors disrupting the teaching and learning process in distance education.

Limitation

This study has several limitations that should be considered. The findings may have limited generalizability beyond the Turkish language and cultural context, as the study focused exclusively on Turkish-language research articles. Therefore, caution should be exercised when applying the findings to other linguistic and cultural settings. Second, the study specifically examined K-12 teachers' experiences during or after the COVID-19 pandemic, which restricts the transferability of the findings to other educational levels or crises. Furthermore, the quality assessment of the selected studies involved subjective judgments influenced by the reviewers' perspectives. Although efforts were made to ensure rigor and reliability, variations in individual

evaluations and interpretations are inherent in qualitative research. Lastly, thematic analysis conducted by two researchers may be subject to interpretation and subjective decisions in identifying themes, which could vary with different analytical approaches or researchers.

Given these limitations, it is vital to interpret the findings of this study cautiously. Further research is needed to broaden the scope, consider diverse cultural contexts, including different educational levels, incorporate alternative literature sources, and employ additional analytical approaches to better understand teachers' experiences with distance education.

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3D MODEL'S ONLINE MODULES EFFECTIVENESS IN PRACTICING MASTERY OF SOLAR SYSTEM CONCEPTUAL KNOWLEDGE

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ABSTRACT

This study aims to describe the 3D model's online modules effectiveness in the practicing mastery of conceptual knowledge in solar system learning using an instrument which tested 58 7th-grade respondents from one of the junior high schools in Jombang, East Java, Indonesia. The respondents were then divided without randomization into 29 respondents for the experimental group (EG), which studied using 3D models online, and 29 respondents for the control group (CG), which studied using learning resources from student books and learning media in the form of 3D models from the NASA website. The effectiveness is assessed based on the results of the conceptual knowledge test instrument with the CRI method using a quantitative descriptive approach. Based on these results, the 3D models online module in solar system

learning cannot be fully effective in the practicing mastery of conceptual knowledge. When examined further, 3D model's online modules are effective in cognitive dimensions C3, learning indicators 1, 2, and 6, and conceptual knowledge sub-types 1. Furthermore, based on research results, learning the solar system using online modules with 3D models is better than using the official NASA website with student books.

Keywords: 3D models, conceptual knowledge, covid-19 pandemic, online module, solar system.

INTRODUCTION

Coronavirus Disease (Covid-19) has become a pandemic and has spread to various countries, including Indonesia (Morfi, 2020). Because of these problems, the Indonesian government immediately takes action to prevent a wider spread, including in the education field (Prodjomaroeto & Muhyidin, 2021). To comply with government policies related to the education system during the pandemic, most schools in Jombang Regency also conduct distance learning by utilizing various online learning services that are most suitable based on the ease and flexibility of the teachers and students (Sofrul, 2021).

New paragraph: use this style when you need to begin a new paragraph. Even during the Covid-19 pandemic, the learning and teaching process should run smoothly with the help of technology. Or even learning that utilizes technology is the new normal in the world of education (Tang et al., 2021). Conventional learning needs to be replaced with learning models related to technology (Marie, 2021). Several reports show the success of the flipped learning model (Birgili et al., 2021; Biyik Bayram et al., 2023; Shin et al., 2022) and blended learning (Marie, 2021; ozturk & Gunes, 2022). This learning will have a great chance of success if applied in urban areas where access to technology is so easy. However, a different story will occur if the model is applied in rural areas. No matter how sophisticated or modern the methods used in learning, it means nothing if learning resources are difficult to access due to various technical problems related to the availability of technological infrastructure, especially for synchronous learning.

The lack of even distribution of internet access in some areas and part of the population having middle to lower economic levels makes some students slow in responding to learning because their parents have not bought big internet quotas (Badan Pusat Statistik Kabupaten Jombang, 2020). In addition to the various challenges encountered in integrating technology, the learning process has accelerated during the Covid-19 pandemic. The use of technology in the world of education should have a positive impact on teachers and students. It is proven that teachers' essential digital and technology-related teaching skills are more important than digital technology resources (Sailer et al., 2021).

The entire world is going through challenging times, but that does not mean we can sit still. The ability to quickly adapt will be very much needed in uncertain conditions like now (Kasali, 2021). Based on this background, the researchers made a temporary conclusion that students in some areas required learning solutions in the form of innovative learning media adapted to students' conditions. This adaptability will appear in every teacher concerned for students and their innovations. Even in a situation like this, the education world should continue to be optimistic, move, adapt, and innovate to meet the ever-changing world (Kasali, 2021).

The dynamics of learning during the Covid-19 pandemic is a challenge to present solutions for teaching solar system material. The dynamics faced make researchers try to innovate with a module that can be accessed by every student quickly even though they cannot meet face to face. It can facilitate them to explore even in cyberspace and make the material studied not too abstract. Therefore, using 3D model's online modules should be tried to practice mastery of conceptual knowledge of the solar system during the Covid-19 pandemic.

Choosing a module as a solution offered for distance learning during the Covid-19 pandemic was the wisest choice because the module has characteristics that students can study independently. Modules can also be studied repeatedly regardless of the place and time of the study. Several studies support this statement by reporting that electronic modules can improve learning outcomes compared to those without electronic modules (Susanti et al., 2020).

The choice of solar system learning for this research is based on the characteristics of the material, which is classified as abstract (Isik-Ercan et al., 2014). Based on the theory of cognitive development, some experts argue that children have limited and qualitatively different reasoning skills and have little difficulty with abstract thinking (Isik-Ercan et al., 2014; Slavin, 2018).

The researchers also chose the solar system material because it was the last material to be taught in the seventh grade even semester in the 2013 curriculum (Peraturan Menteri Pendidikan Dan Kebudayaan Republik Indonesia, 2018). Due to the solar system material being the last material, science education practitioners often needed more time to discuss the material because there needed to be more time to teach all the material. It is unfortunate considering that the solar system material triggers students' curiosity because it is exciting and related to various phenomena that are close to students but challenging to examine the causes and consequences. Therefore, developing online modules with solar system materials that are flexible in terms of study time and can be used as independent learning resources with various limitations is very necessary to be developed.

On the other hand, the world of education is now dominated by Y, Z, and alpha generations who were born at a time when technology was developing rapidly. Research shows that using technology to complement teaching materials will positively impact learning outcomes (Li & Tsai, 2013; Susanti et al., 2020). Electronic-based games with the theme of environmental geoscience are also reported to be able to support the stimulation and effectiveness of student learning (Pringle, 2013). Several studies also said that education based on technology games on materials related to the solar system received positive responses from students (Kadosawa & Makino, 2018; Muntean et al., 2017; Pena & Tobias, 2014; Salazar et al., 2020; Sin et al., 2017).

When examined further, the average age of children at the junior high school level is 12-14. Based on the theory of cognitive development, children at that age are included in the formal operational category. They can start to think abstractly like adults (Slavin, 2018). However, this development is not a process that takes place as quickly as flipping the hand. They need a slow learning process so that this development can optimally run until they reach the adult stage. Therefore, assistance in the form of appropriate learning media is needed for the teaching and learning process to be meaningful for students. Thus, the selection of 3D models that can simulate events related to phenomena around students can provide them with a CL so that they can master abstract knowledge more smoothly, even in learning during the Covid-19 pandemic.

Several studies report that 3D visualization can improve student learning outcomes (Azhar et al., 2021; El Mawas et al., 2020; Merchant et al., 2014; Muntean et al., 2017; Sahin & Yilmaz, 2020; Salazar et al., 2020), can increase student activity in learning with questions, interest, and curiosity (Kadosawa & Makino, 2018; Muntean et al., 2017), as well as a deep understanding of the orbits of the planets in the solar system when introduced in 3D (Kadosawa & Makino, 2018). The existence of 3D models is also reported to be able to make students comfortable and feel immersed when students use virtual reality (Pena & Tobias, 2014) and suitable for junior high school (SMP) students (Azhar et al., 2021).

Motivation theory also plays a role in students' mastery of knowledge. The use of appropriate and sustainable learning media and learning resources in one complete module can help students be intrinsically motivated by presenting challenging activities with various 3D simulations, enabling students to gain control over their learning by taking advantage of the flexibility of online modules or triggering their curiosity about the solar system (Slavin, 2018). The higher the level of students' intrinsic motivation to continue learning will be directly proportional to the mastery of the knowledge they get (Bayoumy & Alsayed, 2021; Oose et al., 2019; Palittin et al., 2019; Tripathi et al., 2018).

When viewed, it is based on information processing theory which states that information entering sensory memory must get the proper attention and perception before it enters working memory (Slavin, 2018). This 3D model is expected to trigger students' good attention and perception to make it easier to understand the material provided by the online module. Teaching materials that utilize computer programs by adding 3D facilities can allow students to repeat the material and make more in-depth observations. This benefit can help students learn about complex concepts more effectively. Information processing theory explains that the proper repetition process can make the information contained by students last longer by entering long-term memory (Slavin, 2018).The opportunity to be repeated as much as possible can be utilized by teachers or students who use 3D model's online modules appropriately so that the information can be more meaningful and last longer in long-term memory.

It should be noted that adding a virtual 3D model also has a negative impact that needs to be anticipated when implementing it in learning. It was reported that when assessed on 5th-grade elementary school students, virtual reality-based learning media made it difficult for students to understand the information text in the game developed (Pena & Tobias, 2014).

Due to various dynamics and challenges faced by learning during the Covid-19 pandemic, the researchers limited the research results to only concluding 58 respondents who were divided into two groups at one of the schools in Jombang, East Java, Indonesia. Researchers also assume that students' study alone or are guided by their parents during the learning process.

METHOD

This study was conducted to determine the effectiveness of 3D model's online modules (Ervana et al., 2022). The fundamental difference from the research is the use of research design intact-group comparison design where respondents are divided into two groups. One group is treated using 3D models online modules, and the other uses learning resources from student books and solar system 3D models from the NASA official website. More concise research flow can be seen in Figure 1.

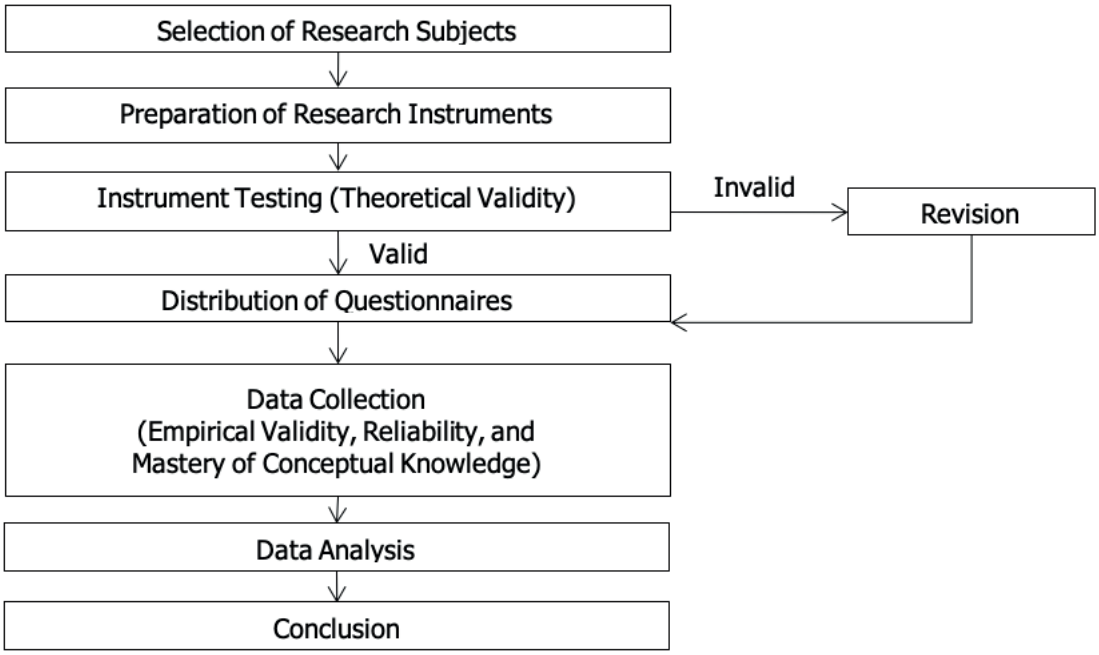

Figure 1. Research flowchart

Participants

The school used for this research is on the outskirts of Jombang Regency, East Java, Indonesia. Most students in the school can only access distance learning using smartphones during the Covid-19 pandemic. The uneven internet access in the area exacerbates the challenge of distance learning. The majority of residents have a lower-middle economic level, and the majority of them work as farmers, making some students relatively slow in responding to learning because their parents have not bought an internet quota (Badan Pusat Statistik Kabupaten Jombang, 2020). The learning conditions at that time were also exacerbated because students were forced to help their parents' economy at certain times, so learning by online meeting was not possible. Two culturally different tribes are participants in this study. The tribes are Javanese and Madurese. However, the distribution of the two tribes in each class the researchers used during the trial had been randomized by the school when determining the study group. So, cultural differences in the trial results can be assumed to have no significant effect.

The school has five study groups in 7th grade. The research trial began by taking two of the five classes with the most feasible learning schedule. The two classes were used as control group (CG) and experimental group

(EG) without randomizing students. As a result, 29 students were included in the EG, and 29 students were included in the EG. Determining students by randomization is not possible because it will interfere with the running of school administration and learning schedules for other subjects. Students' opportunity to get adequate education during the Covid-19 pandemic will also be disrupted and violate human rights.

During the experiment period, both groups were given the same learning method (direct instruction), the same test instrument, and the time and classroom conditions were not much different. Researchers always try to ensure that the results differ from the 3D model's online modules used in EG and student books and learning media in 3D models from the NASA official website used in CG.

Data Collection and Analysis

The instrument consists of 30 multiple-choice questions with the addition of a Certainty of Response Index (CRI). The questions point (QP) were divided into three meetings, each containing ten question points to be assessed. The test instrument used has specifications to measure the student's solar system conceptual knowledge. They are limited to the cognitive dimensions of understanding (C2), applying (C3), analyzing (C4), and evaluating (C5) because it adapts to conditions during the Covid-19 pandemic. Based on the researcher's experience, the cognitive dimension of remembering (C1) was not chosen because it is not suitable to be assessed during distance learning because students can easily search for information on search engines without needing to learn further. In contrast, the cognitive dimension makes (C6) not chosen because researchers find it difficult to supervise and guide students when working on a project during the Covid-19 pandemic lesson.

The cognitive dimension of Understanding (C2) is found in questions 1, 2, 25, 26, 27, 28, 29, and 30. The cognitive dimension of Applying (C3) cognitive dimension is seen in questions 21, 22, 23, and 24. The cognitive dimension of Analyzing (C4) is found in question items 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, and 17. Meanwhile, the Evaluating cognitive dimension (C5) is found in questions 11, 18, 19, and 20. So the total number of questions is 30 questions.

The researcher also used the test instrument's result to determine the competency indicators' achievement. The learning indicator of "Analyze the characteristics of the planets and components of the solar system" is found in question items 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The learning indicator "Evaluating information on the shape of the planet Earth" is only found in question 11. The learning indicator "Analyze the rotational motion and revolution of the Earth and Moon" are located in question numbers 12, 13, 14, 15, 16, and 17. The learning indicator "Evaluate information on the phases of the Moon" is found in questions 18, 19, and 20. The learning indicator "Explain the events caused by the movement of the Earth and the Moon" is seen in questions 25, 26, 27, 28, 29, and 30. While the learning indicators "Applying the impact of the movement of the Earth and Moon on everyday life" are found in question items 21, 22, 23, and 24. So overall, the number of item items is 30.

The researcher divided the research instruments into three categories to measure mastery of conceptual knowledge based on sub-types of conceptual knowledge (Anderson et al., 2001). For the sub-type of conceptual understanding, "Knowledge of classifications and categories," the researcher uses question items 1, 2, 3, 5, 6, A7, 8, 9, and 1. The sub-type "Knowledge of principles and generalizations" uses items question number 21, 22, 23, 24, 25, 26, 27, 28, 29, and 30. As for the "Knowledge of theory, model, and structure" sub-type, use item numbers 4, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20. So overall, the number of item items is 30.

Before being assessed respondents, the validator tested the conceptual knowledge mastery test instrument for its theoretical validity using two expert lecturers and one science teacher. After being declared theoretically valid, Students tested the conceptual knowledge mastery test instrument. The result of instrument theoretical validity is analyzed quantitatively by using the value that often appears (mode) for the three validators. The mode score obtained is then interpreted based on the categories in Table 1.

Table 1. Category for Each Item of Theoretical Validityof Conceptual Knowledge Mastery Test Instruments (Sugiyono, 2018)

No.	Mode	Category
1	1	Not Good
2	2	Fairly Good
3	3	Fine
4	4	Very Good

The results obtained for each aspect are then calculated using the Equation 1.

$$Validity = \frac{the\ total\ score\ of\ results}{max\ score} \times 4 \quad (1)$$

Through this equation, the result of the validity calculation is then concluded based on the criteria in Table 2.

Table 2. Criteria of Theoretical Validity of Conceptual Knowledge Mastery Test Instruments (Budiarso, 2017)

No	Interval Score	Rating Category	Explanation
1	3,51≤P≤4,00	Very valid	Can be used without revision
2	2,51≤P≤3,50	Valid Enough	Usable but needs minor revision
3	1,51≤P≤3,50	Invalid	It is recommended not to use it because it needs major revisions
4	1,00≤P≤1,50	Invalid	Cannot be used

After the test instrument is considered theoretically valid, the instrument is given to the respondent. The results were analyzed using a quantitative descriptive approach. Furthermore, the results of the conceptual knowledge mastery test instrument tested on students are empirically analyzed. In contrast, in empirical validity, the question items in the conceptual knowledge mastery test instrument are said to have internal validity based on how far the grain results are consistent with the overall measuring results of the test. Therefore, the item's validity is reflected in the magnitude of the correlation coefficient between the item score and the total test score. The Pearson product-moment correlation test equation used Equation 2 (Chee, 2016).

$$r = \frac{(n\sum XY)-(\sum X)(\sum Y)}{\sqrt{\{(n\sum X^2)-(\sum X)^2\}\{(n\sum Y^2)-(\sum Y)^2\}}} \quad (2)$$

If this instrument is valid, it can be seen from the interpretation criteria regarding the correlation index (r) in Table 2. Furthermore, the test results are then compared to r_{table} *Pearson product-moment* using a significant level of 5% or 0.05 and the degree of freedom $df = n\text{-}2$ to find out the external validity (Sappaile, 2007). If $r_{result} > r_{table}$ then the item can be said to be valid and if $r_{result} < r_{table}$ then the item can be invalid.

Reliability shows that an instrument can be trusted to be used as a data collection tool because the instrument is already good. This study was conducted using Cronbach's Alpha testing to determine the instrument's reliability in the form of multiple-choice questions. An instrument in the form of reliability is declared reliable if Cronbach's Alpha value contained is at least 0.60. Cronbach Alpha equation show in Equation 3 (Streiner, 2003).

$$\alpha = \left[\frac{k}{k-1}\right]\left[1 - \frac{\sum s_i^2}{s_x^2}\right] \quad (3)$$

The test results are then interpreted with the criteria presented in Table 3. The results of the reliability test of a research instrument are said to be ideal if they get results more than 0.70 or fall into the criteria of good and very good (Wijaya & Darmayanti, 2019).

Table 3. Criteria for interpretation of conceptual knowledge mastery test instrument's reliability (Woollins, 1992)

No.	Score Interval	Interpretation
1	.90 – .00	Excellent
2	.80 – .89	Good
3	.70 – .79	Acceptable
4	.60 – .69	Questioned
5	.50 – .59	Poor
6	< .49	Unacceptable

The method used to identify students' conceptual knowledge mastery uses the Certainty of Response Index (CRI) method. The CRI method is a technique for measuring a person's concept mastery by measuring a person's level of confidence or certainty in answering each question given. The use of the CRI method is also intended to distinguish students who understand the concept, do not know the concept, and experience misconceptions. The scale used in the CRI ranges from 0-5, namely 0 = guessed answer, 1 = almost guess, 2 = not sure, 3 = sure, 4 = almost inevitable, and 5 = certain (Hasan et al., 1999).

The analysis results with CRI are used to distinguish students who know the concept, do not know the concept and those who have misconceptions. The matrix of CRI interpretation results can be seen in Table 4.

Table 4. CRI Criteria (Hasan et al., 1999).

Answer Criteria	Low CRI (<2,5)	High CRI (>2,5)
Correct answer	Correct answer but low CRI (CL) does not master conceptual knowledge. (Lucky Guess)	Correct answer and high CRI (CH) mean mastering the mastery of conceptual knowledge well
Wrong answer	Wrong answers and low CRI (WL) mean that they do not master conceptual knowledge.	Wrong answer but high CRI (WH) means there is a misconception

Identifying the mastery of conceptual knowledge is carried out individually and in groups. Identifying individual misconceptions is done by calculating the percentage of students who experience misconceptions. The percentage calculation is contained in Equation 4, 5, 6, and 7.

$$\%\, WL = \frac{number\ of\ WL\ students}{total\ number\ of\ students} \times 100\ \% \quad (4)$$

$$\%\, CL = \frac{number\ of\ CL\ students}{total\ number\ of\ students} \times 100\ \% \quad (5)$$

$$\%\, WH = \frac{number\ of\ WH\ students}{total\ number\ of\ students} \times 100\ \% \quad (6)$$

$$\%\, CH = \frac{number\ of\ CH\ students}{total\ number\ of\ students} \times 100\ \% \quad (7)$$

The percentage results contained are then grouped into the criteria presented in Table 5.

Table 5. CRI percentage interpretation criteria (Wola, 2020)

No.	Percentage	CRI Criteria
1	.00 – 30.00%	Low
2	30.01 – 60.00%	Medium
3	60.01 – 100.00%	High

From these results, the 3D model's online modules can be said to be effective for practicing the mastery of conceptual knowledge if the percentage results for each CRI identification of misconceptions, do not know the concept, and alleged debts get results of .00 – 30.00%. On the other hand, low criteria, and the identification of CRI master's conceptual knowledge of 30.01 – 100.00% or in the medium or high category (Wola, 2020).

FINDINGS AND DISCUSION

The Instruments Validity

The results of the theoretical validity processing are presented in tabular form in Table 6.

Table 6. Grouping the theoretical validity of conceptual knowledge mastery test instruments based on categories

No.	Category	Amount	Percentage (%)
1	Very valid	5	8.33
2	Quite Valid	55	91.67
3	Less Valid	0	0
4	Invalid	0	0
Total		**60**	**100**

The Pearson Product Moment correlation test was used to determine the empirical validity of the conceptual knowledge instrument results. The results of the empirical validity of the conceptual knowledge mastery test instrument grouped based on the criteria and meetings conducted are presented in Table 7

Table 7. Grouping of Empirical Validity of Conceptual Knowledge Mastery Test Instruments Based on Criteria and Meetings

No.	**Criteria**	**EG**		**CG**	
		QP	**Total**	**QP**	**Total**
1	Valid	2, 7, 8, 9, 12, 18 and 30	7	3, 7, 14, and 15	4
2	Invalid	1, 3, 5, 9, 10, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, and 29	23	1, 2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, and 30	26
3	Undefined	4, and 11	2	-	0
Total			**30**		**30**

The reliability test has a relationship with the consistency of the score and is genuinely relevant when there is a consequence to the interpretation that will be contained (Henson, 2001). The results of the reliability test of a research instrument are said to be ideal if the results are more than .70 (Wijaya & Darmayanti, 2019). However, reliability refers to the evaluation instrument's results and not the instrument itself. So, it is correct to talk about the reliability of 'test scores' or 'measurements' rather than 'tests' or 'instruments' (Henson, 2001). The results of the conceptual knowledge mastery test instrument's reliability test, divided into three meetings in learning, are presented in Table 8.

The effectiveness of the 3D model's online modules is seen using a conceptual knowledge mastery test instrument with the addition of the CRI method. This CRI method has advantages and disadvantages. The advantage is that it is simple and can be used at various levels (high school to college), while the disadvantage is that this method depends on the student's honesty (Waluyo et al., 2019). Another area for improvement of the CRI method lies in categorizing the level of understanding of students who have a low level of confidence and the magnitude of the guess factor of students in answering questions because the form of questions used is a multiple-choice test. For example, if there are students who master conceptual knowledge but because they have a low level of confidence, they get a low CRI scale and are grouped in the category of not mastering conceptual knowledge or are considered guessing answers (Hakim et al., 2012). However, the CRI method is needed to determine the level of student mastery of learning material, especially in distance learning which is difficult to supervise. However, the CRI method is needed to determine the level of student mastery of learning material, especially in distance learning which is difficult to supervise.

Table 8. Reliability Grouping of Conceptual Knowledge Mastery Test Instruments

No.	QP	EG		CG	
		Reliability	Interpretation	Reliability	Interpretation
1	1, 2, 3, 4, 5, 6, 7, 8, 9, and 10	.66	Questioned	.49	Unacceptable
2	11, 12, 13, 14, 15, 16, 17, 18, 19, and 20	.08	Unacceptable	.25	Unacceptable
3	21, 22, 23, 24, 25, 26, 27, 28, 29, and 30	.24	Unacceptable	.54	Poor

The Percentage of CRI during Trials

The results of the answers from the conceptual knowledge mastery test instrument were further analyzed using the Certainty of Response Index (CRI) method. In the trial, two analytical results were contained because two treatments were conducted. The results of the analysis were divided based on the control class and the experimental class are presented in Figure 2.

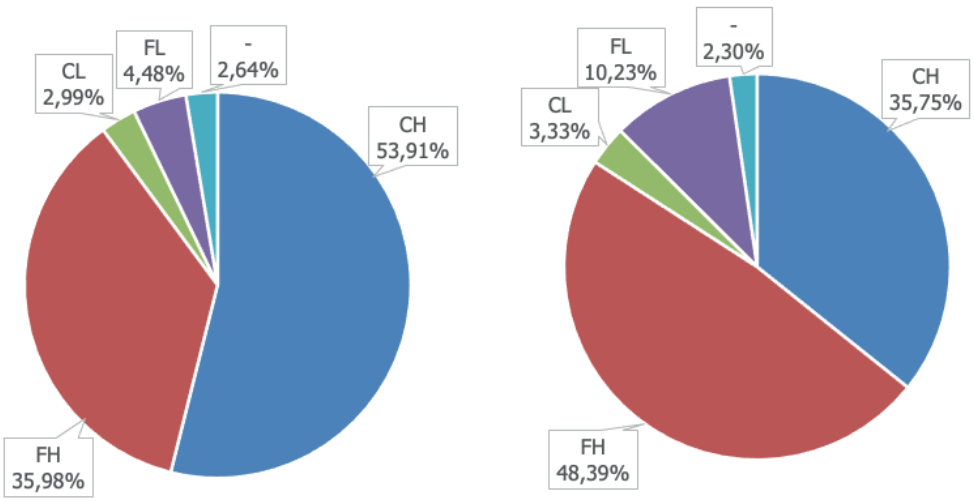

Figure 2. Percentage of CRI during trial on (a) EG and (b) CG

The results of trials in the EG are presented in Figure 2.a. Based on these results, and it is known that overall, 53.91% of students can master conceptual knowledge (CH) in the medium category. On the other hand, 35.98% of students experience misconceptions (FH) in the medium category, 2.99% answer correctly because of luck (CL) in the low category, and 4.48% of students have not been able to master conceptual knowledge (FL) in the low category. In addition to these results, it should also be remembered that 2.64% of students cannot be concluded. Based on these results, a temporary conclusion can be made that the learning conducted in the EG using 3D model's online modules also cannot be effective in practicing mastery of conceptual knowledge. That result is because even though 53.91% of students get the medium category in practicing conceptual mastery (CH). However, 35.98% of students in the moderate category need clarification.

The results of the trial in the CG are presented in Figure 2.b, containing information that overall, 35.75% of students can master conceptual knowledge (CH) in the medium category. On the other hand, 48.39% of students experience misconceptions (FH) in the medium category, 3.33% answered correctly because of luck (CL) in the low category, and 10.23% of students had not been able to master conceptual knowledge (FL) in the low category. In addition to these results, it should also be remembered that 2.30% of students cannot be concluded. Based on these results, learning in the CG cannot be said to be effective in practicing mastery of conceptual knowledge. Because although 35.75% of students fall into the medium category in practicing conceptual mastery (CH), 48.39% of students experience misconceptions and fall into the medium category.

Even looking at the overall treatment of EG and CG is ineffective. The result shows that the level of mastery of conceptual knowledge is in the medium category. That result is because technology-based learning resources that students can use to study at any time can be a solution during the Covid-19 pandemic (Jou et al., 2016; Sletten & Montebello, 2021). Several researchers report that learning by utilizing learning resources can train mastery of conceptual knowledge (Amir et al., 2020; Cai, 2021; Rittle-Johnson & Schneider, 2014).

Conversely, misconceptions are also included in the medium category for EG and CG. The occurrence of misconceptions during distance learning cannot be avoided, however. If students experience misconceptions or fail to master concepts correctly, they will have difficulty solving problems, resulting in low learning outcomes (Soeharto & Csapo, 2022). Many factors lead to misconceptions about distance learning, one of which is the passivity of students and the need for more social interaction (Darici et al., 2021). Researchers can reduce misconception potential by being even more careful in choosing each instruction so students get a better learning experience (Lapitan et al., 2023). Therefore, an online module containing 3D models results in lower misconceptions than learning that utilizes the official Nasa website and student books. However, this cannot be said to be effective because the results of misconceptions are still in the moderate category.

Because based on the results of the trials conducted, the two treatments did not get effective results due to the level of a misconception that was still above 30.00%. The researchers then conducted a more profound analysis by grouping based on the dimensions of cognitive processes, Learning Indicators (LI), and conceptual knowledge sub-types (SKST) (Anderson et al., 2001).

CRI for Cognitive-based Conceptual Knowledge

The grouping of the results of trials based on the dimensions of cognitive processes is intended to provide a comprehensive set of classifications for students' cognitive processes that are included in the learning objectives (Anderson et al., 2001). The dimensions of cognitive processes analysed in this study are C2 (understanding), C3 (applying), C4 (analysing), and C5 (evaluating). The analysis results based on the dimensions of cognitive processes are presented in Figure 3.

The results of the mastery of conceptual knowledge test in the EG showed that 53.88% of students had mastered conceptual knowledge of the C2 cognitive process dimensions with moderate criteria. The cognitive process dimension C2 is a learning objective to construct the meaning of instructional messages, including oral, written, and graphic communication (Anderson et al., 2001). Meanwhile, 38.79% of students experienced misconceptions with low criteria, 2.16% correctly answered because luck was in a low category, and 3.45% of students had yet to succeed in mastering conceptual knowledge on the C2 cognitive process

dimension. In the CG, the results were 47.84% of students mastered the cognitive process dimensions C2 with moderate criteria, 37.50% in the medium category, students answered correctly because of luck, 5.60% in the low category, and 8.62% of students have not mastered conceptual knowledge with low category on the cognitive process dimension C2. Using 3D models as learning media offers a deeper and more accurate understanding (Olivieri, 2019). 3D models should also minimize misconceptions about the material being studied (Grant & Olivieri, 2017). However, the result can conclude that the EG and CG cannot effectively practice mastery of conceptual knowledge of the cognitive process dimensions of C2 because both treatments contained misconceptions that fall within the moderate criteria. However, when viewed from the number of students who managed to master conceptual knowledge, the learning carried out in the EG using 3D model's online modules got higher results than CG. So, learning with 3D model's online modules is better than learning using the official NASA website.

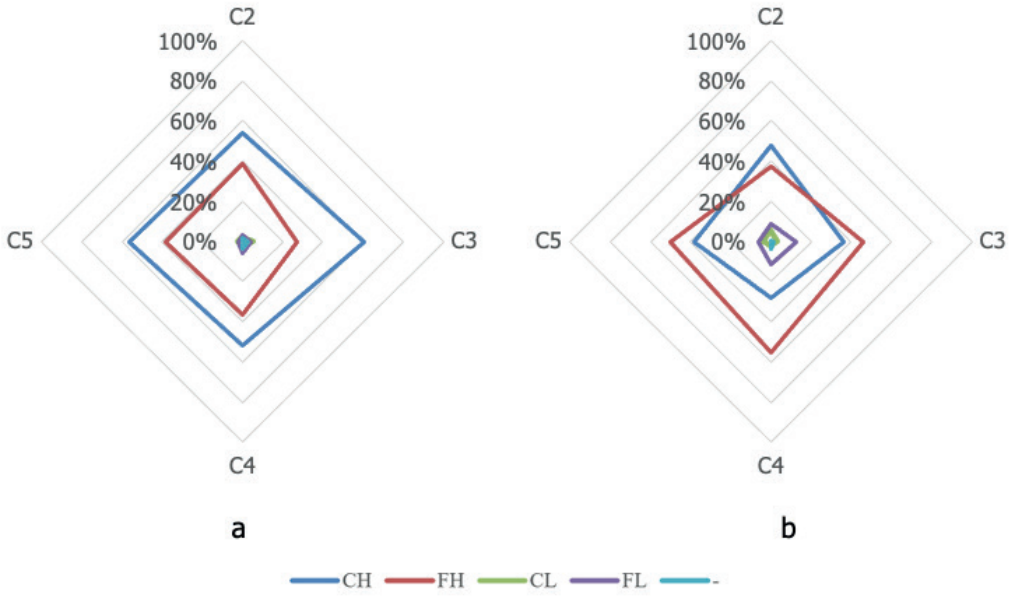

Figure 3. Recapitulation of CRI results on conceptual knowledge mastery test instruments based on cognitive dimensions during trial on (a) EG and (b) CG

In practice, the cognitive process dimension C3 is a learning goal that requires students to routinely carry out procedures when faced with unfamiliar tasks (Anderson et al., 2001). In the EG, information was contained that 60.34% of students had succeeded in mastering conceptual knowledge with moderate criteria. In contrast, 27.59% of students had misconceptions with low criteria, 5.17% answered correctly because of luck with low criteria, and 4,31% of students have not mastered the conceptual knowledge of the C3 cognitive process dimensions with low criteria. While in the CG, the results showed that 36.21% of students had mastered conceptual knowledge of the C3 cognitive process dimensions in the moderate category. On the other hand, 45.69% of students experienced misconceptions in the medium category, 2.45% of students answered correctly because of luck in the medium category, and 12.93% of students have not been able to master the conceptual knowledge of the C3 cognitive process dimensions. Based on these results, using 3D models in learning should help in mastery of the C3 cognitive dimension because several studies have reported that 3D models can provide visual simulations that can help with training (Bauch et al., 2019). Based on these results, in the trial, the mastery of conceptual knowledge of the C3 cognitive process dimensions carried out in the CG could not be practical because the level of misconceptions experienced by students was included in the moderate criteria. On the other hand, the EG using 3D model's online modules can be practical because the results of mastering conceptual knowledge of the C3 cognitive process dimensions fall into the medium criteria and the level of misconceptions falls into the low criteria.

The cognitive process dimension C4 is a learning goal to break down the material into its constituent parts and determine how the parts relate to each other and the overall structure or purpose (Anderson et al.,

2001). This cognitive dimension requires higher-order and complex thinking skills. The EG trial showed that 51.48% of students had mastered conceptual knowledge with moderate criteria. On the other hand, 36.21% of students experienced misconceptions with moderate criteria, 2.96% of students managed to answer correctly because of luck with low criteria, and 5.91% of students have not been able to master the conceptual knowledge of the cognitive process dimensions of C4 with low criteria. In the CG trial, information was contained that 28.08% of students succeeded in mastering conceptual knowledge of the C4 cognitive process dimensions with low criteria. On the other hand, 54.93% of students experienced misconceptions with moderate criteria, 1.97% of students answered correctly because of luck with criteria low, and 11.58% of students have not been able to master the conceptual knowledge of the cognitive process dimensions of C4 with low criteria. Based on these results, the learning in the EG and CG cannot be said to be effective in practicing mastery of conceptual knowledge of the C4 cognitive process dimensions. These results from the misconceptions that are included in the medium criteria. However, the CG and EG results cannot be effective. Learning in the EG is better than learning in the CG because the results of mastery of conceptual knowledge of the cognitive process dimensions of C4 learning in the EG are higher than learning in the CG.

Regarding 3D model simulation in the developed online module, researchers are trying very hard to make each object like the actual object. However, some adjustments need to be made (and cannot be avoided) to make it comfortable to use and display optimally on various devices and hardware specifications. These adjustments will affect the student's perspective on the 3D objects he observes. The limitation of the system that supports 3D models in the learning modules developed in displaying data is also a critical factor in the ineffectiveness of the 3D online modules developed in this study in practicing conceptual mastery of the C4 cognitive process dimension.

Finally, the trial results will be presented based on the conceptual mastery test for the C5 cognitive process dimension. The cognitive process dimension C5 is a learning goal to make judgments based on criteria and standards (Anderson et al., 2001). In the EG, information was contained that 56.03% of students had mastered conceptual knowledge of the C5 cognitive process dimensions with moderate criteria. On the other hand, 37.93% of students had misconceptions with moderate criteria, 2.59% of students could answer correctly because of luck, and 1.72% of students have not been able to master the conceptual knowledge of the C5 cognitive process dimensions with low criteria. Meanwhile, in the CG, 37.93% of students were able to master the conceptual knowledge of the C5 cognitive process dimensions with moderate criteria. On the other hand, 50.00% of students experienced misconceptions with moderate criteria, 3.45% of students managed to answer correctly because of luck with low criteria, and 6.03% of students have not been able to master conceptual knowledge with low criteria. Based on the results, it can be concluded that learning conducted in the EG and CG cannot be effective in mastering conceptual knowledge because it has a misconception rate of 50.00% of students for the CG and 37.93% of students with moderate criteria. However, based on these results, it can also be concluded that learning using 3D model's online modules is better than learning using the NASA official website and student books. These results were obtained from 56.03% of students who have mastered higher conceptual knowledge for EG and 37.93% for CG.

CRI for Learning Indicators

Competency Achievement Indicators (LI) are behaviors that can be measured and observed to be concluded in the fulfillment of essential competencies in core competencies (KI-3) and (KI-4) to be concluded. Both become a reference for the assessment of subjects (Peraturan Menteri Pendidikan Dan Kebudayaan Republik Indonesia, 2014). In the trial, six indicators were observed: (1) Analyzing the characteristics of the planets and components of the solar system; (2) Evaluating information on the shape of the planet Earth; (3) Analyzing the rotational motion and revolution of the Earth and the Moon; (4) Evaluating information on the phases of the Moon; (5) Explaining events due to the movement of the Earth and Moon; and (6) Applying the impact of the movement of the Earth and Moon on daily life. The results of the analysis based on LI are presented in Figure 4.

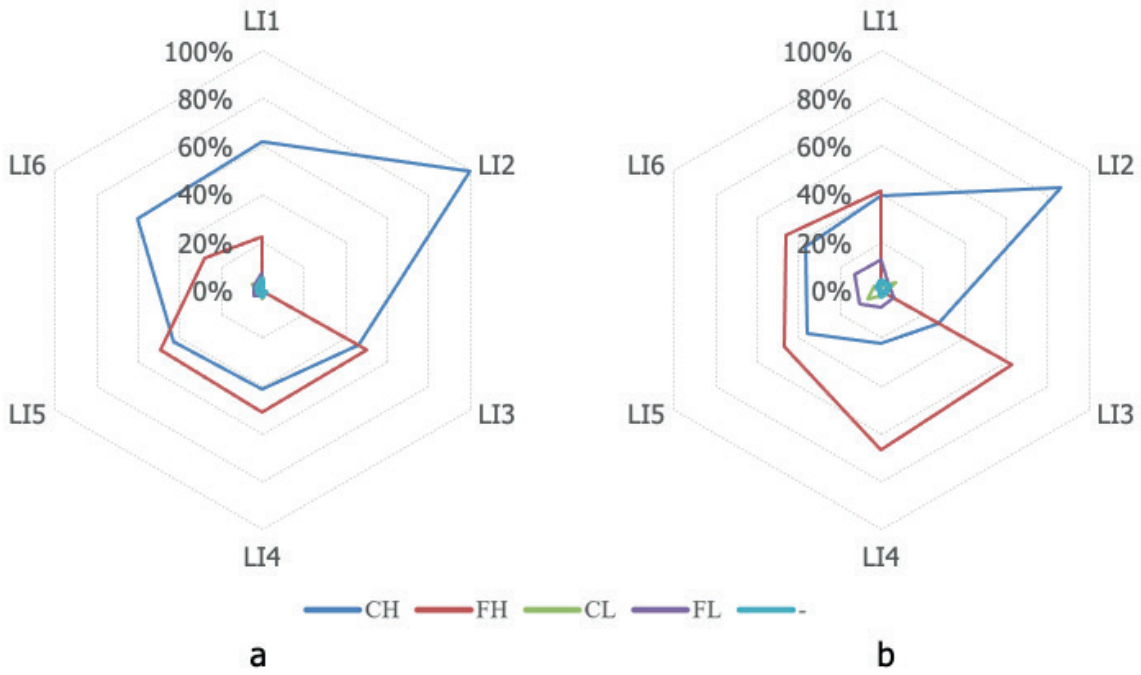

Figure 4. Recapitulation of CRI Results on Conceptual Knowledge Mastery Test Instruments Based on Learning Indicators (LI) during Trial on (a) EG and (b) CG

The results of the first learning indicator (LI1), which reads "analyzing the characteristics of the planets and components of the solar system" in the large group trial of the control class obtained results of 39.66% of students have successfully mastered conceptual knowledge (CH) with moderate criteria, 41.38% of students experienced misconceptions (FH) with moderate criteria, 2.07% of students managed to answer correctly due to luck (CL) with low criteria, and 13.10% of students have not been able to master conceptual knowledge (FL) with low criteria. The indicator's results "analyse the characteristics of the planets and components of the solar system" 61.72% of students had mastered conceptual knowledge (CH) with moderate criteria in the EG. On the other hand, 22.07% of students experienced misconceptions (FH) in the low criteria. However, 4.14% of students felt they did not understand the concept and answered lucky (CL) in the low category, and 7.59% did not master conceptual knowledge (FL) in the low category. Based on these results, the 3D model's online modules lesson are practical because it gets the results of mastering conceptual knowledge of LI1 in the medium category, and students who experience misconceptions are in a low category. On the other hand, learning using the NASA official website and student books in the CG cannot be said to be effective for practicing mastery of conceptual knowledge because the results of the level of misconception are in the moderate category.

For the second learning indicator (LI2), which reads "evaluating the information on the shape of the planet Earth," In the EG, it was found that 100.00% of students had mastered the concept (CH) with high criteria. No students had misconceptions (FH), answered correctly because of luck (CL), and had not mastered conceptual knowledge (FL). Meanwhile, in the CG, it was found that 86.21% of students had mastered the concept (CH) with high criteria. There are no students who have misconceptions (FH). However, 6.90% of students feel that they answered correctly because of luck (CL) with low criteria, and 3.45% of students have not been able to master conceptual knowledge correctly (FL) with low criteria. Based on these results, the two treatments, both the CG and EG as well as the CG, can be effective because the mastery of students' conceptual knowledge is included in the high criteria for the CG and EG. If the EG and the CG are compared, it can be concluded that learning using 3D model's online modules used in EG learning is better than learning using the NASA official website and student books in the CG at LI2.

The results of the third learning indicator (LI3), which reads "analyze the rotational motion and revolution of the Earth and the Moon" in the EG, showed that 45.98% of students had succeeded in mastering the concept (CH) with moderate criteria. However, as many as 50.00% of students experienced misconceptions (FH)

with moderate criteria. In comparison, 1.72% of students responded correctly because of luck (CL) with low criteria, and 1.15% had not mastered the concept (FL) with low criteria. Meanwhile, in the CG, 27.59% of students had mastered the concept (CH) with low criteria, and 62.64% had misconceptions (FH) with high criteria. In comparison, 1.72% of students responded correctly because of luck (CL) with low criteria, and 5.75% had not mastered the concept (FL) with low criteria. Based on these results, learning in the CG and EG cannot be said to be effective in practicing LI3 conceptual knowledge. These results are obtained because the results of students who successfully master conceptual knowledge fall into the low criteria, and students who experience misconceptions fall into the moderate criteria in the CG. For learning in the EG, although students who have succeeded in mastering conceptual knowledge of LI1 are included in the moderate criteria, students experiencing misconceptions are also included in the moderate criteria. Based on these results, learning with 3D model's online modules is better than using the NASA official website and student books.

The fourth learning indicator (LI4), which reads "evaluating the information on the phases of the Moon," that the EG got a result of 41.38% of students had succeeded in mastering the concept (CH) with moderate criteria. Meanwhile, 50.57% of students experienced misconceptions (FH) with moderate criteria, 3.45% of students answered correctly because of luck (CL) with low criteria, and 2.30% of students did not understand the material (FL) with low criteria. Meanwhile, the CG received information that 21.84% of students had mastered the concept (CH) with low criteria. Meanwhile, 66.67% of students experienced misconceptions (FH) with high criteria, 2.30% of students answered correctly because of luck (CL) with low criteria, and 6.90% of students needed help understanding the material (FL) with low criteria. Based on these results, the learning in the CG and EG cannot be said to be effective in practicing mastery of conceptual knowledge. In the CG, the results of the mastery of conceptual knowledge with an LI4 were included in the moderate criteria. However, the level of misconceptions was also included in the moderate criteria. Meanwhile, even though the mastery of conceptual knowledge of LI4 also received moderate criteria in the EG. The resulting misconceptions are also included in the moderate criteria. However, based on these results, 3D model's online modules in the EG can be said to be better than learning using the official NASA website and student books in the CG.

The fifth learning indicator (LI5), which reads "explaining events due to the movement of the Earth and Moon," showed that 43.10% of students had succeeded in mastering the concept (CH) with moderate criteria in EG. On the other hand, 49.43% of students experienced misconceptions (FH) with moderate criteria, and 1.15% answered correctly because of luck (CL). With low criteria, and 4.60% of students need help understanding the material (FL) with low criteria. Meanwhile, the CG contained results of 35.63% of students having mastered the concept (CH) with moderate criteria. On the other hand, 46.55% of students experiencing misconceptions (FL) in the medium category, 6.90% of students answered lucky (CL) in the low category, and 10.92% of students have not mastered conceptual knowledge (FL) in the low category. Based on these results, the learning conducted in the CG and EG cannot be said to be effective in increasing students' mastery of conceptual knowledge. Although the level of mastery of students' knowledge is in the medium category, the level of students' misconceptions is also in the medium category. Based on these results, it can also be concluded that learning using 3D model's online modules models is better than NASA's official website and student books because of the higher mastery of conceptual knowledge and lower misconceptions.

The last one is the sixth learning indicator (LI6) which reads "applying the impact of the movement of the Earth and Moon in everyday life," where 60.34% of students had mastered conceptual knowledge (CH) with moderate criteria in EG. On the other hand, 27.59% of students experienced misconceptions (FH) with moderate criteria, 5.17% of students managed to answer correctly because of luck (CL) with low criteria, and 4.31% of students have not mastered conceptual knowledge (FL) with low criteria. While in the CG contained the results of 36.21% of students having mastered conceptual knowledge (CH) with moderate criteria. On the other hand, 45.69% of students experiencing misconceptions (FH) with moderate criteria, 3.45% of students successfully answered true because of luck (CL) with low criteria, and 12.93% of students have not mastered conceptual knowledge (FL) with low criteria. Based on these results, both the learning in the CG and EG cannot be said to be effective in practicing mastery of conceptual knowledge of LI6 because the misconceptions contained are included in the moderate criteria in the CG and EG. Based on these results, it can also be concluded that learning using the official NASA website and student books is better than 3D model's online modules in terms of practicing mastery of LI6 conceptual knowledge.

CRI for Conceptual Knowledge Mastery

Conceptual knowledge includes knowledge of categories, classifications, and relationships between and among them (a more complex and organized form of knowledge). Conceptual knowledge includes schemas, mental models, or theories implicit or explicit in different cognitive psychological models. These schemas, models, and theories represent an individual's knowledge about how a particular subject matter is organized and structured, how different pieces or bits of information related to each other more systematically, and how the parts function together (Anderson et al., 2001). The results of the analysis of the conceptual knowledge test instrument in the trial were also grouped into three subtypes are presented in Figure 5, namely: (1) Knowledge of classification and categories; (2) Knowledge of principles and generalizations; and (3) Knowledge of theory, model, and structure.

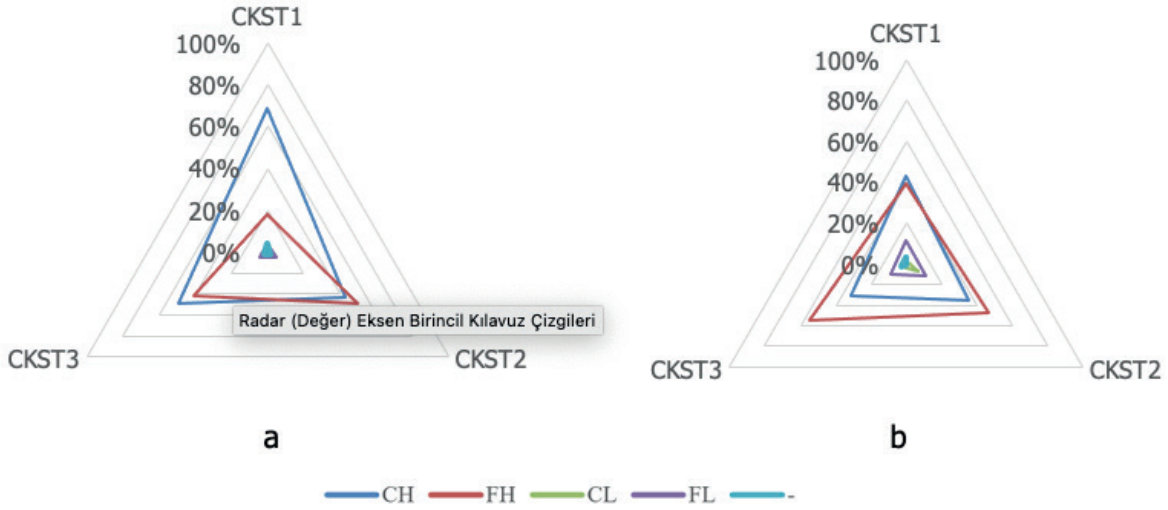

Figure 5. Recapitulation of CRI Results on Conceptual Knowledge Mastery Test Conceptual Knoledge Sub-Type (CKST) during Trial on (a) EG and (b) CG

For the first conceptual knowledge sub-type (CKST1), which reads "knowledge of classifications and categories," the materials observed are (1) Knowledge of the characteristics of planets in the solar system, (2) Knowledge of the characteristics of the components that make up the solar system; and (3) Knowledge of the inner and outer planets in the solar system. The EG showed that 68.58% of students had mastered the first conceptual knowledge sub-type (CKST1) (CH) with moderate criteria. On the other hand, 18.39% of students experienced misconceptions (FH) with low criteria, 4.60% felt they did not understand the concept and answered correctly because of luck (CL) with low criteria, and 4.21% of students did not master the sub-type. Conceptual knowledge (CKST1) (FL) with low criteria. In the CG, 43.31% of students have mastered the first conceptual knowledge sub-type (CH), which reads "knowledge from classification and categories" with moderate criteria. On the other hand, 39.46% of students experienced misconceptions (FH) with moderate criteria, 2.30% of students felt that they answered correctly because of luck (CL) with low criteria, and 11.88% of students did not master the first conceptual knowledge sub-type (FL) with low criteria. Based on these results, both the learning in the CG using the official NASA website and student books cannot be said to be effective because the level of students' misconceptions is in the medium category. Meanwhile, learning using 3D model's online modules is effective for training the first conceptual knowledge sub-type because it has successfully trained mastery of conceptual knowledge to the medium category and misconceptions to the low category. These results are because the virtual 3D model applied to learn can increase student learning motivation so they can enjoy the teaching and learning process more (Afnan et al., 2021; Akcayir et al., 2016; Akcayir & Akcayir, 2017; Zhang et al., 2014).

In the second conceptual knowledge sub-type (CKST2), which reads "knowledge of principles and generalizations," the materials observed are (1) Knowledge of eclipses, (2) Knowledge of tides, (3) Knowledge

of the division of the moon (sidereal and synodic); and (4) Knowledge of the daily and annual apparent motion of the Sun. The EG showed that as many as 43.10% of students had mastered the sub-type (CH) with moderate criteria. However, as many as 49.43% of students experienced misconceptions (FH) with moderate criteria, 1.15% of students felt that they answered correctly because of luck (CL) with low criteria, and 4.60% of students had not mastered the second conceptual knowledge sub-type (FL) with low criteria. Meanwhile, 35.63% of students in the CG have mastered the conceptual knowledge sub-type (CH) with moderate criteria. However, 46.55% of students experienced misconceptions (FH) with moderate criteria, and 6.90% felt that they answered correctly because of luck (CL) with low criteria. Meanwhile, 10.92% of students have not mastered the second conceptual knowledge sub-type (FL) with low criteria. Based on these results, both the CG and EG cannot be effective because students who experience misconceptions fall into the moderate criteria for students in the CG and the EG. Based on these results, learning 3D model's online modules developed in the EG is better than learning the official NASA website and student books in the CG. Based on these results, it is an evaluation material that one of the drawbacks of implementing virtual 3D models is that the design process is quite tricky so that the working principle resembles the original object (H. Y. Chang et al., 2022; K. E. Chang et al., 2014).

The last is the third sub-type (CKST3) which reads "knowledge of theory, model and structure" the material observed in that sub-type is: (1) Knowledge of rotational and revolutionary motion; (2) Knowledge of viable and uninhabitable planet opportunities; (3) Knowledge of planetary models; (4) Knowledge of the model components that make up the solar system; (5) Knowledge of the changing shape of the moon when viewed from the earth; and (6) Knowledge of the structure of the Sun. From the EG, 49.43% of students mastered the third conceptual knowledge sub-type with moderate criteria. On the other hand, 41.15% of students experienced misconceptions with moderate criteria, 2.76% of students answered correctly because of luck with low criteria, and 4.60% of students had not been able to master the conceptual knowledge sub-type with low criteria. Meanwhile, in the CG, 31.26% of students have mastered conceptual knowledge (CH) with moderate criteria, and 54.48% have misconceptions (FH) with moderate criteria. Meanwhile, 2.53% of students answered correctly because of luck (CL) with low criteria, and 8.97% of students had not mastered the third conceptual knowledge sub-type related to knowledge of theory, model, and structure (FL) with low criteria.Based on these results, learning in the CG and EG cannot be said to be effective in practicing mastery of conceptual knowledge sub-types because the level of misconceptions experienced by students is in the medium category. However, if we look further, it can be concluded that learning 3D model's online modules used in the CG is better than learning the official NASA website and student. These results are obtained because the level of students who have mastered the third conceptual knowledge sub-type in the EG is higher than CG. he use of 3D models in learning does have many positive impacts, but virtual 3D model media developers should do development more carefully during the design and evaluation process. (H. Y. Chang et al., 2022) as well as pay attention to the impact and level of efficiency (Akpan & Shanker, 2017).

Based on observations, the presence of 3D Model's online modules can slightly support learning during the Covid-19 pandemic, especially in rural areas where technological and economic limitations are not sufficient for the continuity of synchronous learning. Although more complex than using learning resources from the official NASA website, 3D Model's online modules are adequate and adapted to the conditions of rural students so that they can be considered alternative learning resources during the Covid-19 pandemic because they have better performance.

CONCLUSION

Based on the results of the study, it can be concluded that in general 3D model's online modules are less effective in practicing mastery of conceptual knowledge. In general, of 3D model's online modules still cannot be said to be effective in practicing mastery of conceptual knowledge because 53.91% of students can master conceptual knowledge in the medium category, 35.98% of students experience misconceptions in the medium category, 2.99% answer correctly because luck is in the low category, and 4.48% of students have not been able to master conceptual knowledge in the low category. In addition to these results, it should also be remembered that 2.64% of students cannot be concluded. Based on these results, a temporary conclusion can be made that the learning carried out in the experimental class using of 3D model's online modules

cannot be said to be effective in practicing mastery of conceptual knowledge because even though students' mastery of conceptual knowledge is in the medium category, the level of misconceptions that occurs is also included in the medium category.

Although the of 3D model's online modules cannot be said to be effective in practicing mastery of conceptual knowledge, the results are still better than learning in the control class where 35.75% of students can master conceptual knowledge in the medium category, 48.39% of students experience misconceptions in the medium category, 3.33% answered correctly because of luck in the low category, and 10.23% students have not been able to master conceptual knowledge in the low category. In addition to these results, it should also be remembered that 2.30% of students cannot be concluded. Based on these results, it can be concluded that learning in the control class using the NASA website cannot be said to be effective in practicing mastery of conceptual knowledge because even though students' mastery of conceptual knowledge is in the medium category, the level of misconceptions that occurs is also in the medium category.

Limitations and Suggestions for Future Studies

The effectiveness of the online module with 3D models was tested using a conceptual knowledge mastery test instrument. In the large group trial, the online module with 3D models cannot effectively practice mastery of conceptual knowledge. No one drug can treat all diseases; the online module with 3D models developed also has advantages and disadvantages that need to be observed when used in learning. The researcher has conducted a sub-analysis to determine the strengths and weaknesses of the developed online module. With the sub-analysis, the development of this online module or similar modules can be more easily done.

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ONLINE STUDENT ENGAGEMENT IN THE TURKISH CONTEXT: A PRISMA-BASED SYSTEMATIC REVIEW

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ABSTRACT

The ability to interact or engage with the instructor, other students, and the content i.e., to experience online student engagement, is one main difference between traditional and digital media employed in teaching and learning processes. As literature on this topic in the Turkish context has proliferated, to date, virtually no systematic reviews of this research have been carried out in order to identify potential gaps in the literature. To address this issue, this study investigated previously conducted research in chronological order on student engagement at the post-secondary level in the Turkish context using a PRISMA-based systematic review screening process. The results show that online engagement research and practices have clearly increased and diversified over time. Specifically, online engagement research in the Turkish context has tended to focus on computer science students studying in online-only, LMS-supported environments where their behavioral engagement has been investigated quantitatively. Considering these findings, this systematic review suggests that future studies in the Turkish context should examine other fields besides computer science education, focus more on collaborative tools and the social dimension of engagement, use more qualitative methods, and investigate blended environments as well as online-only.

Keywords: Online engagement, engagement, distance education, e-learning, systematic review.

INTRODUCTION

For more than two decades, numerous studies have been conducted to reveal the effectiveness of teaching approaches comparing distance education and face-to-face education in terms of different variables. Most of these studies have investigated the extent to which classroom learning and teaching processes can be transferred to technology-supported environments. While most of the studies have shown that distance education is at least as successful as education in a face-to-face classroom environment, it is generally understood from many of these studies, that the difference between these two types of learning environments is not particularly meaningful or significant (see Nguyen, 2015; Ramage, 2002). In this regard, simply using technology to facilitate a lecture or presentation-based learning process in the classroom, i.e., a teacher-centered approach, adds little, if anything, to the educational environment. In contrast, a learning process in which technology has been used to facilitate a student-centered approach has often yielded more promising findings (Trinidad & Ngo, 2019; Bates, 2015). The most problematic aspect of distance education has always been the inability to foster adequate two-way classroom communication in digital environments, namely, the "interaction" variable. However, advances in technology in recent years have impacted this variable positively, making this criticism less valid than it once was, especially with enhancements in the quality of such two-way communication.

ONLINE STUDENT ENGAGEMENT

The main differentiating factor between traditional and digital media used in teaching and learning processes is the ability to interact, or engage with the educator, other students, and the content. The basic process of communication for learning processes is a two-step process: First, the messenger (educator) sends a message through a medium. Second, the message is received and decoded by the learners. In face-to-face environments, where traditional media like blackboards, smart boards or computer-projection systems are used, the process is primarily one-way. In contrast, in online environments, where digital media like video conferencing and learning management systems are used, users have greater abilities to interact and respond to the message—in other words, they can 'engage' with the message and messenger (eCampusOntario, 2018).

Ultimately, all instructional activities are communication processes and, in this process, the message, that is, the teaching content, is as important as the tools and methods. Online interaction not only occurs between instructors and learners, but also with the content (Anderson, 2009). Hence, as also stated by Anderson (2003), "Differentiating between high and low levels of interactivity is largely a quantitative exercise in which a researcher, developer, or the participants themselves, count the number of times they are actively engaged with the other participants or content" (p. 7). With these insights in mind, one can conclude that interaction causes an increase in engagement. However, just as there are various interaction types that cause engagement, it is clear that there

are also different types of engagement. Thus, Redmond, Abawi, Brown, Henderson, and Heffernan (2018) proposed a five-part "Online Engagement Framework for Higher Education" (Figure 1 below). Their purpose was to provide a conceptual framework for student engagement to be used as a planning and auditing tool to guide educators in order to improve engagement among online learners. Redmond and his colleagues (2018) proposed a theoretical view of student engagement including five interrelated elements that provide a tool for instructors, instructional designers, and researchers to facilitate and evaluate online student engagement.

To be begin with, social engagement refers to students' actions and investments leading to collegiate experience as defined by Knight (2013) which has been previously mentioned in the community of inquiry model as "social presence" by Garrison, Anderson, and Archer (2000). This type of engagement can be witnessed in the use of social forums, and open communication platforms like social media. Here, informal, and social interactions are addressed beyond formal study requirements such as work and study relationships. Thus, indicators of social engagement are building community, creating a sense of belonging, developing relationships, and establishing trust.*Cognitive engagement* refers to students' involvement in the learning process to create meaning out of content, reflect on it, and break down complex ideas and difficult skills in a detailed way (Fredricks, Blumenfeld, and Paris, 2004). These ideas have been previously mentioned in the community of inquiry model as "cognitive presence" by Garrison, Anderson, and Archer (2000). This type of engagement can be observed as the use of mental abilities like judgement, justification, integration, exploration, decision making, and deriving conclusions. Thus, indicators of cognitive engagement are thinking critically, activating metacognition, integrating ideas, justifying decisions, developing deep discipline understandings, and distributing expertise.

Figure 1. Engagement Framework for Higher Education (adopted from Redmond, Abawi, Brown, Henderson & Heffernan, 2018, p. 189

Behavioral engagement refers to students' observable actions and evidence for involvement in the learning tasks such as adhering to rules and norms, asking questions, contributing to discussions (Fredricks, Blumenfeld & Paris, 2004), demonstrating high effort and persistence as well as self-regulating behaviors (Cheng, Liang, & Tsai, 2013; Young, 2010). This type of engagement shows similarity with "teaching presence" which also appears in the community of inquiry model by Garrison, Anderson, and Archer (2000). This type of engagement can be observed in academic reading, writing, and listening, planning, time management, and goal setting (Pittaway & Moss, 2014). Thus, indicators of behavioral engagement are developing academic skills, identifying opportunities and challenges, developing multidisciplinary skills, developing agency, upholding online learning norms, and supporting and encouraging peers.

Collaborative engagement refers to students' interaction with their peers, instructors, and other educational stakeholders to build networks and relationships to support the learning process. The use of supportive learning environments for students to collaborate is extremely important for effective integration of group activities and assessment in learning processes. This type of engagement can be observed in the collaborative use of tools for data sharing, image editing, idea exchange and discussion where many of the web 2.0 tools provide support. Thus, indicators of collaborative engagement are learning with peers, relating to faculty members, connecting to institutional opportunities, and developing professional networks.

Emotional engagement refers to students' involvement in subjective and objective variables of the learning process through a complex set of interactions which is also mentioned as "emotional presence" by Cleveland-Innes and Campbell (2012). Students' feelings and attitudes play an important role in learning since emotions not only modulate virtually every aspect of cognition but also motivate social behaviors (Tyng, et. al., 2017). This type of engagement is discernible in the form of interests, values, and emotions (Fredricks, Blumenfeld, & Paris, 2004). Thus, indicators of emotional engagement are managing expectations, articulating assumptions, recognizing motivations, and committing to learning.

Although there are different terms and definitions (including ones not mentioned here) used for addressing the engagement of students in their learning processes, the merging of these concepts in order to define human aspect in learning is quite obvious. Thus, in addition to the many other variables that affect the learning ecosystem, it is important to understand the role and importance of the term "engagement" in achieving effective and efficient learning outcomes.

WHY IS ONLINE ENGAGEMENT IMPORTANT FOR LEARNING?

Since every learning process is based on the exchange of information in the form of two-way interactions, it is obvious that each student has to maintain presence in these interactive learning situations through engaging in the activities. Hence, there are many studies that aim to reveal how this engagement occurs in different virtual environments, attempting to provide evidence in support to demonstrate that such engagement has occurred. We know from many studies that interactivity promotes active collaborative learning and engagement which has great potential to improve students' learning performance. Consequently, active collaborative learning improves students' engagement and learning performance (Blasco-Arcas, et. al., 2013).

In the literature, various instruments and methods that aim to measure different types of online engagement can be seen. These include self-report scales, interviews, observations, experience sampling, teacher ratings, eye-tracking, physiological sensors, log files, and content analysis (Greene, 2015; Fredricks & Mccolskey, 2012). Each instrument and each method have its own strengths and weaknesses. Different measurements can be used in combination to allow researchers to triangulate and establish the validity of the data (Greene, 2015).

The most utilized approach in assessing cognitive engagement is self-report scales. According to the literature, three streams of self-report measures exist. These include scales that measured: 1. motivations related to the school (e.g., students' beliefs about the value of schooling or control of schoolwork) 2. learning strategy use (i.e., self-regulatory, cognitive, and metacognitive strategies) 3. mental involvement or psychological investment of the students, including effort, persistence, and dedication (Fredricks & Mccolskey, 2012).

The next method that has been used to measure students' cognitive engagement is interviews. Researchers often asked the students for further explanations of their prospective or retrospective behaviours in structured interviews in order to obtain information about students' strategy use (Dent & Koenka, 2016). Another method for measuring cognitive engagement is observational methods at both the individual and classroom levels (Fredricks & Mccolskey, 2012). Some research (Helme & Clarke, 2001; Greene, 2015; Lee & Anderson, 1993) verifies that cognitive engagement can be reliably recognized by specific behavioral and linguistic indicators.

Experience Sampling Method (ESM) is yet another method for assessing student cognitive engagement, generally involving the use of electronic or digital devices to interrupt students in order to examine their thoughts and feelings during a specific learning moment (Xie et al., 2018). This method's most important characteristic feature is that students' feelings, thoughts, actions, etc. are measured regularly during an experience in an authentic context (Zirkel et al., 2015).

Teacher ratings are another measurement method for assessing students' cognitive engagement. The Reading Engagement Index (REI) developed by Wigfield et al. (2008) can be given as an example. It was developed for teachers to rate the engagement of each student in a reading task. Yet another measurement method is eye-tracking, which collects the eyes' positions and movements of students to infer their cognitive engagement (Antonietti, Colombo, & Nuzzo, 2015; D'Mello et al., 2017; Miller, 2015). Physiological methods such as electrodermal activity (EDA), electroencephalograph (EEG), electromyogram (EMG), etc. aim to measure the electrical signals produced in the skin. This also provides researchers with physiological data to make inferences about the cognitive and emotional states of the participants (Stevens, Galloway, & Berka, 2007; D'Mello et al., 2017). Since the log files provide information about students' learning activities in computer-based learning environments, cognitive engagement can also be assessed by extracting the students' cognitive and metacognitive strategies through logs of learners' behaviors (Chen & Pedersen, 2012; Bernacki et al., 2012). Content analysis is the last method of measurement of students' cognitive engagement. It detects the students' use of verbal languages or written materials (Tausczik & Pennebaker, 2010; Ireland & Henderson, 2014).

Even though the notion of behavioral engagement is well developed and has been explored in numerous studies in face-to-face settings, student behaviors in online settings are shown to be different (Louwrens & Hartnett, 2015). The nature of involvement in online learning, however, does not differ much from that defined by fundamental definitions of the term in traditional educational environments (Casimiro, 2015). The most used tool for measuring behavioral engagement is scales. Behavioral engagement scales, in which several of the items, such as attention and participation, reflect domain specific aspects of engagement, including emotional disengagement indicators such as frustration, anxiety, confusion; deep strategy use such as solving problems in various ways; and social engagement such as sharing ideas, building ideas, and collaborating with others. There are many other classroom observation instruments and protocols for measuring engagement of the students such as the Reformed Teaching Observation Protocol (RTOP; Piburn et al., 2000), VaNTH Observation System (VOS; Harris & Cox, 2003), STROBE (O'Malley et al., 2003), and the Classroom Observation Protocol for Undergraduate STEM (COPUS; Smith, Jones, Gilbert, & Wieman, 2013). In their article, Lane, and Harris (2015) developed a new measurement tool for Measuring Student Behavioral Engagement in Large University Classes, titled 'Behavioral Engagement Related to Instruction' (BERI) protocol, which can provide timely and formative feedback to the course instructor in the form of a graphical representation of student engagement.

Online learning allows students to interact and cooperate with other students while also engaging in active learning with the course content. Students willingly share their learning with other students in collaborative learning activities. This participation, in turn, stimulates and fosters interactions among students, who share their perspectives and explore new ideas while building on their existing knowledge, resulting in deeper learning. There are some tools that are used to measure the quality of collaboration. For instance, in their study, Lyndall and Elspethth (2015) utilized the two tools for assessing the quality of students' participation in the online learning process. These pedagogical tools are the Conservational Framework and Social Network Analysis (SNA).

The engagement scales assess the behavioral, emotional, and cognitive engagement aspects including persistence, disaffection, anxiety, planning, study management and so on. For instance, Motivation and Engagement Scale (MES), utilized by Martin (2009) comprises 11 scales, which assess indicators of students' engagement and motivation including study management, self-confidence, learning focus, persistence, planning, school valorization, disaffection, anxiety, self-sabotage, failure avoidance, and uncertain control. The Engagement Rating Sheet, developed by Reeve, Jang, Carrell, Jeon & Barch (2004) for trained raters to visit classrooms during learning process in the classroom to observe students' engagement, aimed to assess behavioral, emotional, cognitive, and agentic engagement.

Another tool of measurement is Engagement vs. Disaffection with Learning (EDL; Skinner, Furrer, Marchand, & Kindermann, 2008). The EDL is a 20-item instrument, which aims at behavioral and emotional engagement. This instrument assesses both the presence of engaged learning (behavioral and emotional engagement) and its absence (behavioral and emotional disaffection) (Veiga, 2014).

Compared with face-to-face environments, the major criticism for years was the lack of interaction in online learning environments. Since each learning process is based on different patterns and types of interaction, researchers tried to reveal this phenomenon from different perspectives. The abovementioned studies reveal

that much research has been conducted on this topic over several years. However, as most of the preceding studies were based on online education in western context, there is a clear need to collate and synthesize research in non-western contexts, in which cultural factors could play a significant role, with a view to improving practice and increasing interaction through digital tools and environments. This motivation has led to the design of the current study, which aims to reveal the current situation regarding online engagement in the Turkish context, exploring the types of online engagement research as reflected in the published literature on the target context.

The research was informed by a single overarching research question: How can a PRISMA-based systematic review contribute to a general understanding of an online engagement research within the Turkish context?

RESEARCH QUESTIONS

This study relies on the systematic review, a well-established methodology for conducting bibliographical research in order to synthesize key findings within a specific research area across a wide range of academic sources. Zawacki-Richter et al. (2020) note that "[i]n contrast to traditional or narrative literature reviews, that are criticized as being biased and arbitrary, the aim of a systematic review is to carry out a review that is rigorous and transparent in each step of the review process, to make it reproducible and updateable" (p. 161).

Nested within the research questions outlined in the introduction section above, several topic-specific sub-research questions were identified as a necessary means to conducting the systematic review as follows:

1. What key research trends and findings are discernible within this area in terms of
   - 1.1 year of publication?
   - 1.2 discipline of study?
   - 1.3 research methodology?
   - 1.4 platforms, technologies, and software?
   - 1.5 pedagogical strategy?
2. What are the emerging types of online engagement?
3. What are emerging themes based on the findings of the articles reviewed?

METHOD

This research constitutes a subsidiary component of a larger multinational research endeavor that focuses on the subject of online engagement within the Middle Eastern region. The geographical scope of this overarching project encompasses the Middle Eastern countries of Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, Turkiye, and the United Arab Emirates. Our involvement in this comprehensive initiative centers on the representation of the Turkish segment of this research, underscoring our specific focus on this distinct regional context.

This study employed a *Systematic Review* methodology, which is a type of literature review where the goal is to identify all studies relating to a specific topic through extensive database searches and multi-person screening of results using a precisely defined protocol. As a result, the systematic review approach is fairly broad. In other words, the application of this method means a detailed evaluation and interpretation by accessing various research sources on a particular research question and topic (Kitchenham, 2004). Specifically, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) systematic review approach was adopted for this study due to its widely recognized value as a thorough, transparent, and replicable method (see Page et al., 2021; Rethlefsen et al., 2021; Selcuk, 2019; Moher et al. 2015; Moher et al., 2009).

Regarding systematic review in general, it is beneficial for educational research in many aspects. It can provide access to the literature which has an ever-growing publication basis. Systematic reviews are clear about how the researcher has sourced the information, which ensures credibility and accountability for the literature review. Also, by not allowing researchers to "hide inside" the discourse of the account of knowledge, the systematic review makes visible the inherent biases, exposing, as it does, the conceptual and value orientations of several sources at once (Gough, 2007). Moreover, systematic reviews in higher education are highly sought

after and frequently cited due to their recognized reliability, which in turn, improves research and reporting quality. Systematic reviews can also help educational scholars expand on their existing work by highlighting specific strengths and flaws in the literature as mentioned in the introduction above. This method also helps researchers and practitioners understand and influence the overall practice and status of higher education research at the same time (Bearman et al., 2012). Figure 2 highlights the methodological procedures that were taken in order to perform the systematic review while keeping all of the aforementioned factors in mind.

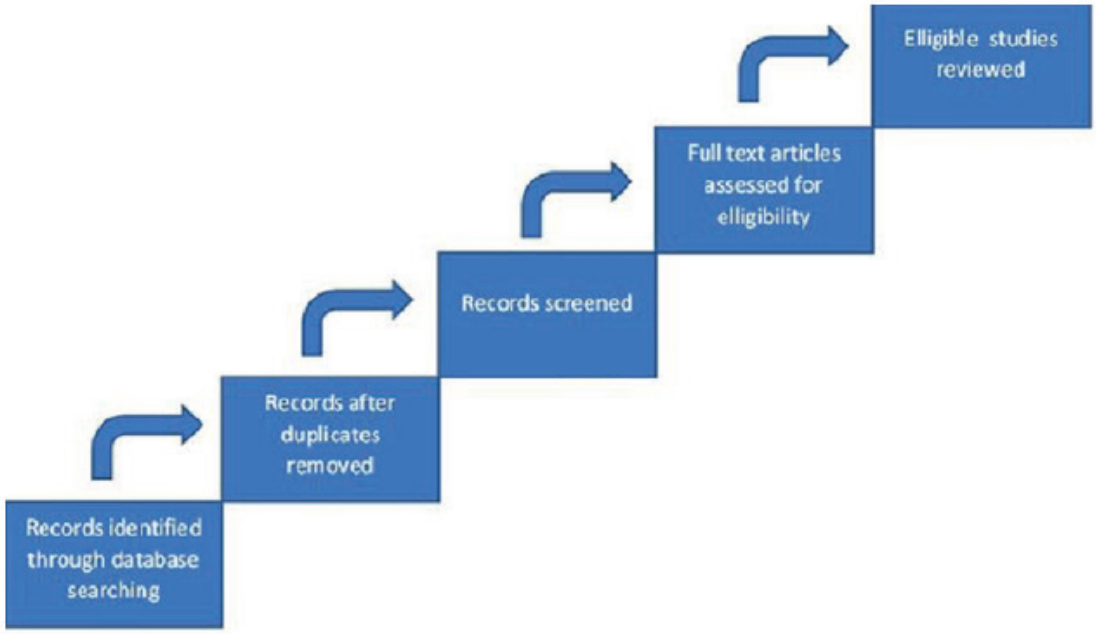

Figure 2. Steps In the Study

Generally consisting of three stages, should be taken to conduct systematic review research by various steps (Carver et al., 2013). These three stages followed in this study are respectively; firstly, planning phase, which is using for selecting the database to investigate, defines the key criteria for whether the investigation called in the selected database is included in the investigation and the content is achieved according to corresponding criteria, and the second phase is execution which means determining the study and the last phase is documentation which is also reporting process for findings.

1) The planning phase includes:
   Motivation for conducting the review
   Research questions
   Search strategy (search strings, databases)
   Methodology for locating primary studies (inclusion, exclusion criteria)
   Creating form for data extraction
2) The execution phase includes:
   Identifying relevant research using the search strategy
   Selecting primary studies using the inclusion and exclusion criteria
   Evaluating selected studies using the quality assessment criteria
   Extracting required data using the data extraction forms
   Analyzing extracted data and synthesize resulting information to draw conclusions
3) The documentation phase includes:
   Defining the dissemination strategy
   Formatting the review report

As can be seen from the steps mentioned above, the motivation for conducting this review was to know what scholars had studied about online engagement in higher education and how their research focus has changed based over several years including the early Covid-19 pandemic period.

Procedurally, first, literature searches were conducted in November of 2020, utilizing a combination of keyword and subject heading searches conducted in multi-language databases (Academic Search Premier, ERIC, PsycInfo, ProQuest, Scopus, Web of Science) as well as the Turkish database Dergipark. Database searches were limited by year from 1995 to present and the language for the publications was set to "Turkish" in multi-language databases (see Appendix). During title/abstract and full- text screenings, inclusion and exclusion criteria were applied to determine eligibility (see Table 1 below).

Table 1. The Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Online or hybrid learning	K-12 education
Student engagement	Face-face learning only
Academic research	
1995-2020	
Higher education	
Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, Turkiye, United Arab Emirates, West Bank and Gaza, Yemen	

To limit selection bias, screenings were conducted by four of the authors (ESO, HA, DC, YG). All articles were screened by at least two reviewers and conflicts were resolved by one of the remaining reviewers. In order to prevent the inclusion of off-topic sources in the final collection of research articles, several exclusion criteria, i.e., terms that would disqualify a source on the grounds that it was not relevant to the research focus on online post-secondary were identified as follows: Personal narratives/autoethnography, PPT/Prezi presentations, K-12 education, Blogs, and Correspondence (snail mail) learning.

The final search resulted in 1366 studies from all databases, and these were imported for screening into Covidence systematic review platform. 234 duplicate studies were removed automatically. 1132 studies were screened by researchers, 937 studies were marked as irrelevant. 185 full-text studies were assessed for eligibility, 95 studies were excluded because of the reasons such as wrong sample, wrong setting, wrong study design, wrong language, wrong outcomes. Finally, 90 studies were included in the systematic review process. Descriptive quantitative analysis was used for the first two research questions whereas qualitative inductive approaches were selected for the analysis of the third research question.

Data Collection

As previously delineated, the present study serves as a subordinate component of a multinational research project. In accordance with the parameters established by the project initiators, data collection was undertaken by the implementation of various search strings (see Appendix). As the Turkish research group, we collected data within the DergiPark database, selected for its user-friendly interface, comprehensive article coverage, and compatibility with the specific requirements of our data collection process. The imperative needs associated with the execution of a large-scale systematic review necessitated the utilization of this database, as it facilitates advanced research through the application of Boolean operators (i.e., "and," "or," "not"), permits the filtration of search outcomes by several indicators. Furthermore, it is essential to download the research results, including abstract, title, and author, in an appropriate format for the Covidence (https://www.covidence.org/) systematic review platform. Subsequently, upon successfully downloading the search results in a designated file format, the acquired data set was uploaded to the Covidence platform. Moreover, studies pertaining to the Turkish context, identified during the search processes conducted by research groups from other countries, were integrated into the Covidence platform.

The culmination of the research process yielded a total of 1366 scholarly investigations from diverse academic databases, all of which were subsequently imported into the Covidence systematic review platform for further examination. Automatically, 234 redundant studies were extracted, thereby streamlining the corpus for meticulous scrutiny. We as Turkish researchers then diligently reviewed the remaining 1132 studies with title and abstract only, culminating in the determination of 937 as bearing no relevance to the subject matter at hand. Following this initial screening phase, we conducted a comprehensive assessment of the eligibility of 185 full-text studies, leading to the exclusion of 95 studies due to a range of factors, including incongruent sample selection, inappropriate contextual settings, inapposite study designs, linguistic disparities, and incongruous outcome measures. Ultimately, a discerning and judicious review process resulted in the inclusion of 90 studies in the systematic review, as visually depicted in Figure 3.

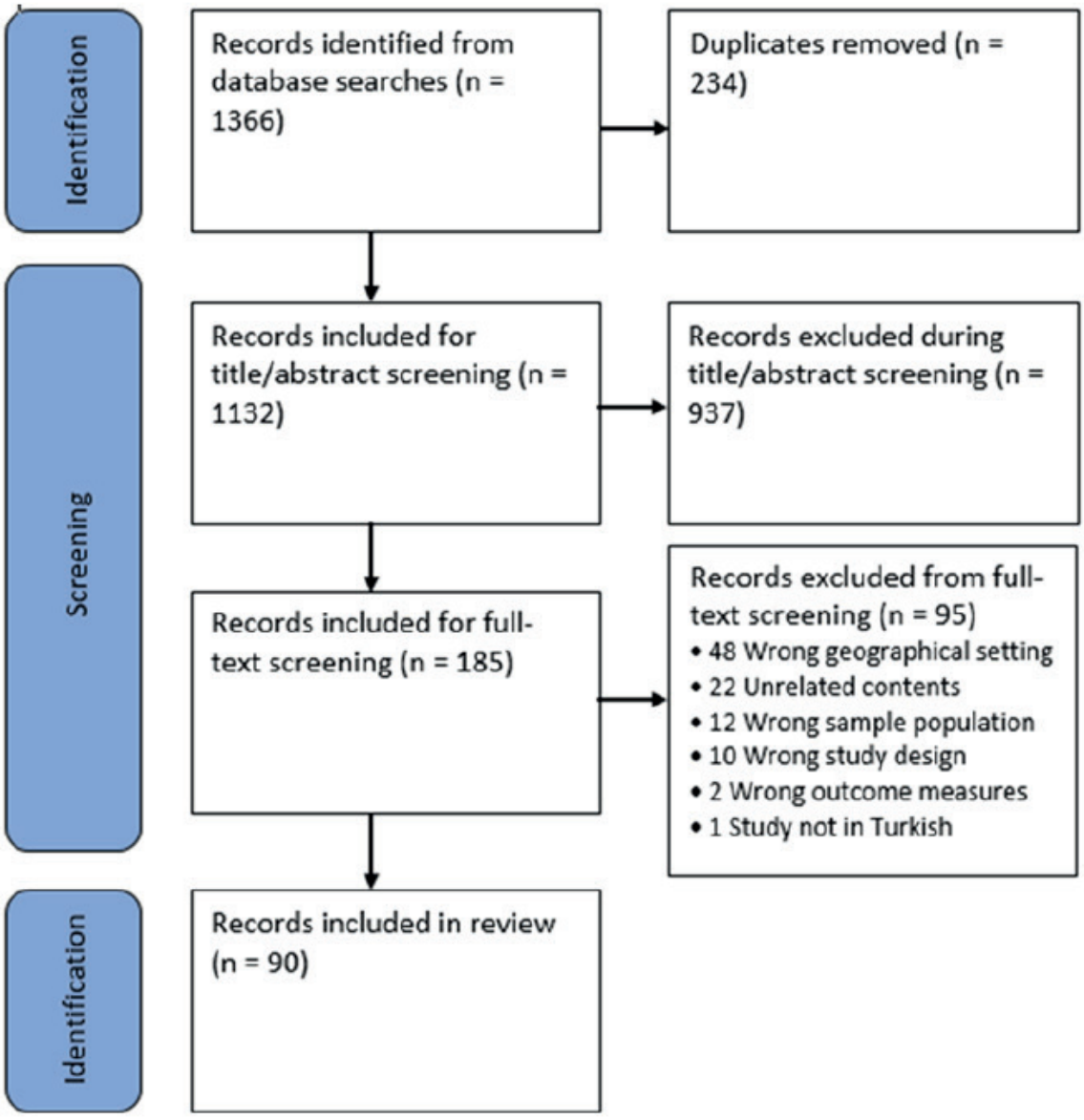

Figure 3. The Process of Systematic Review

Addressing the validity and reliability of data collection processes is pivotal in ensuring the robustness and trustworthiness of our research endeavors. In the context of our systematic review, a meticulous approach was undertaken to enhance both the validity and reliability of the collected data. To establish data validity, stringent inclusion and exclusion criteria were employed during the screening process. This entailed the careful selection of studies that were most pertinent to our research objectives. Additionally, the research team utilized standardized protocols and guidelines to assess the eligibility of full-text studies, ensuring that each study contributed directly to the research questions under investigation. Moreover, inter-rater agreement among researchers was monitored to minimize subjectivity in the inclusion and exclusion of studies. Reliability in data collection was reinforced through consistent and well-documented procedures. Detailed documentation was maintained at each stage of the study selection process, from initial database searches to the final inclusion decisions. In cases where potential ambiguities arose, discussions were held among the research team to reach a consensus. This process of maintaining clear and comprehensive records and engaging in iterative discussions contributed to the reliability of the data collection and ensured the consistency of decision-making throughout the study selection process. These measures were integral to the validity and reliability of the data collection procedures, ultimately underpinning the integrity of the systematic review and enhancing the trustworthiness of the research outcomes.

Data Analysis

A rigorous and transparent data analysis process is fundamental to ensuring the validity and robustness of our research. Our data analysis procedures were tailored to address the specific research questions and involved both quantitative and qualitative methodologies.

For the first two research questions [(1) What key research trends and findings are discernible within this area? (2) What are the emerging types of online engagement?)] we employed a descriptive quantitative analysis approach. Descriptive quantitative analysis aims to identify patterns within data to determine the characteristics of a specific phenomenon or the world at large, addressing questions about who, what, where, when, and to what extent. It simplifies data, providing extensive information on capabilities, needs, methods, practices, policies, populations, and settings, customized to specific research or policy inquiries (Loeb et. al, 2017). Descriptive quantitative analysis (DQA) is a research method used to summarize and present data in a structured and interpretable manner, typically involving the use of numerical and statistical techniques (Creswell, 2017). This approach is particularly useful when researchers aim to describe and understand the key characteristics of a dataset without making inferences or predictions (Vogt & Williams, 2011).

The analysis of the third research question [(3) What are emerging themes based on the findings of the articles reviewed?] adopted a qualitative inductive approach. This entailed a more interpretive and in-depth exploration of the data to identify patterns, themes, and insights that could not be adequately captured through quantitative means (Smith, 2015). Qualitative data, such as textual information and thematic content, were systematically reviewed and analyzed using established qualitative research methodologies, such as thematic analysis or content analysis. This qualitative analysis allowed for a deeper understanding of the nuances and contextual factors surrounding the research question.

Throughout the data analysis process, the research team adhered to a transparent and systematic approach. Analytical decisions, coding schemes, and interpretations were documented, and regular discussions were held to ensure consistency and rigor. By employing a combination of quantitative and qualitative methods, our data analysis aimed to provide a comprehensive and refined perspective on the research questions, enhancing the validity and reliability of our findings.

FINDINGS

The findings of the qualitative analysis derived from the articles are presented in parallel with research questions where some findings are presented in quantitative terms while others are presented as emerging themes.

Current Situation of Studies about Online Engagement for Turkish Context

Number of the Reviewed Articles according to Year of the Publication

The articles in which online engagement is studied have been increasing yearly. As seen in Figure 4 below, papers on this topic started to be published beginning in 2008. Of these, approximately 80% of the papers were published after 2016. In 2015, the Journal of Open Education Practices and Research (AUAd) started to be published and the discipline of Open and Distance Learning was accepted as an associate professorship field by the Interuniversity Board of Turkiye, which may account for the marked increase in articles on this topic between 2016-2018. The second sharp increase is seen in the year 2020, the beginning of the COVID-19 pandemic, which shifted attention to online learning for obvious reasons.

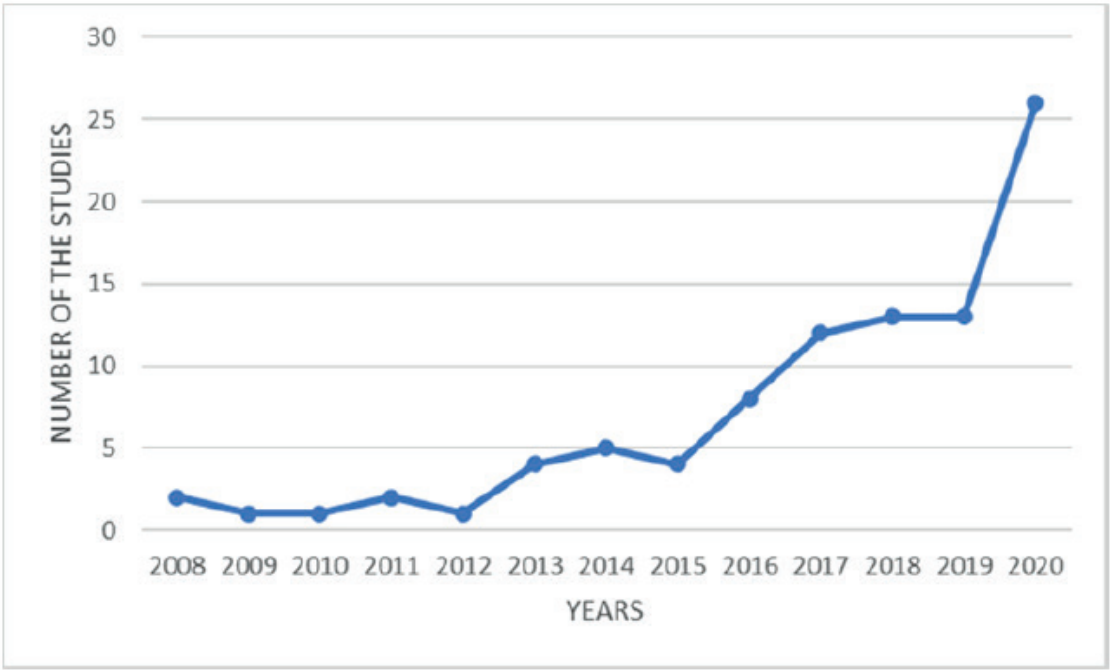

Figure 4. Number of the Reviewed Articles According to the Year of the Publication

Distribution of the Reviewed Articles according to the Discipline

It is seen that most of the studies are in the field of computer science with 28% of studies (except for not specified) when the distribution according to the field of study is examined (Figure 5 below). Computer science is followed by the educational sciences (18%) and language disciplines (10%). The fact that online engagement has mostly been studied in the fields of computer and educational sciences suggests that there is overlap between online education (which typically involves computer use), computer science, and educational science. Thus, in the Turkish context, it is fair to say that computer science and educational sciences appear to be the most connected fields to distance and online education.

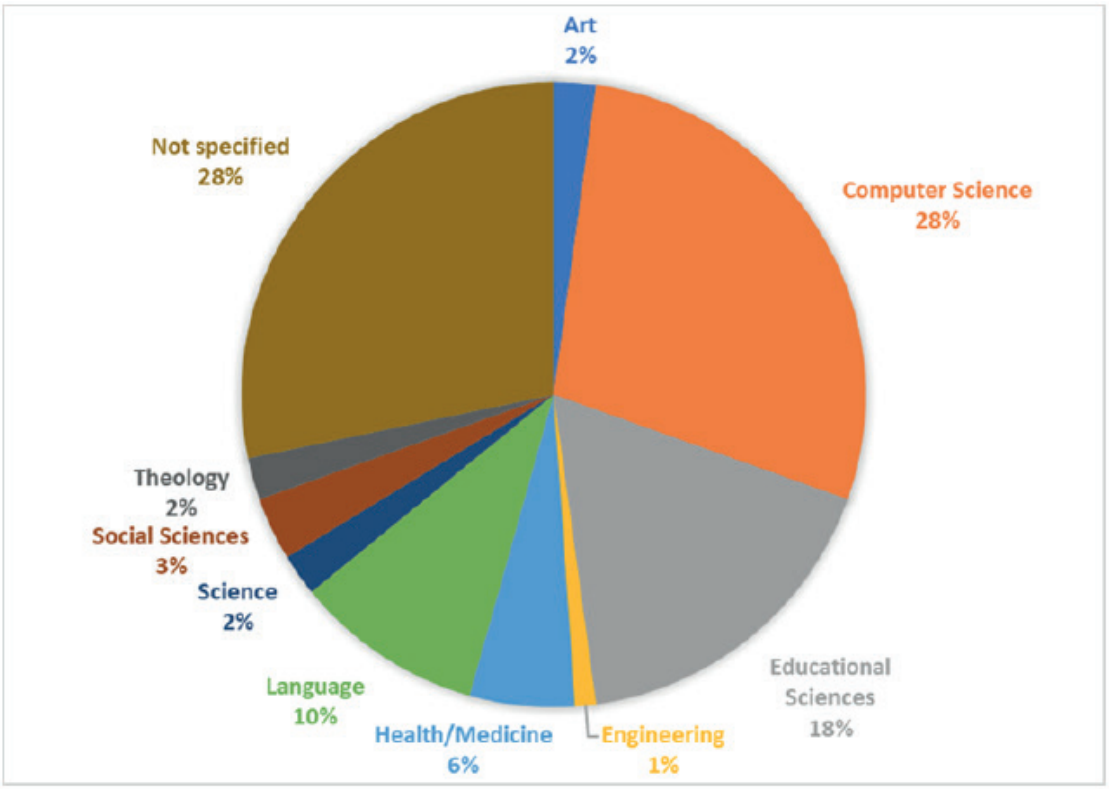

Figure 5. Distribution of the Reviewed Articles According to the Discipline

Distribution of the Reviewed Articles according to the Data Collection Type

As seen on Figure 6 below, most of the studies collected made use of quantitative methods (56%). Quantitative methods were followed by qualitative methods (23%). Only 12% of studies were mixed. As a data collection tool, questionnaires were used mostly i.e., 42 papers out of 92 studies in total. 12 studies were experimental studies with control groups while 26 studies were descriptive.

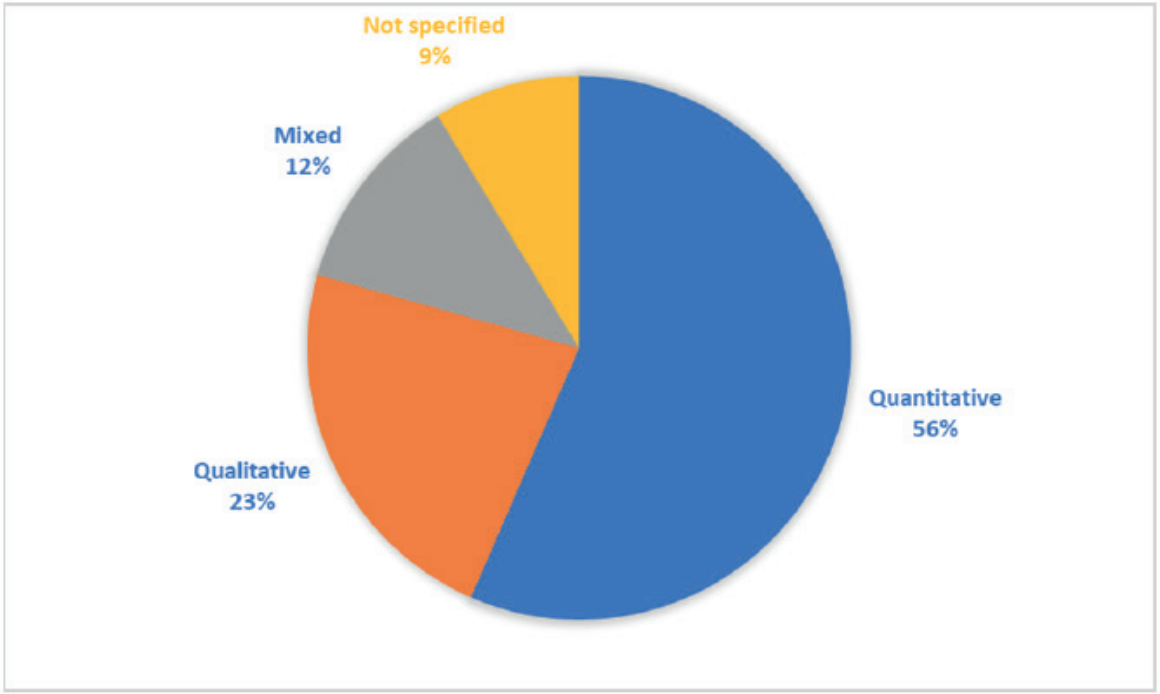

Figure 6. Distribution of the Reviewed Articles According to the Data Collection

Distribution of the Reviewed Articles according to the Platforms, Technologies, and Software

As seen on Figure 7 below most of the studies (36%) used a Learning Management System (LMS) like Blackboard, Canvas, Moodle, Google Classroom, Edmodo, Angel, WebCT, Sakai, D2L and Brightspace as the online platform. While 5% of the studies used social media platforms such as Facebook, Twitter, Discord, Instagram, WhatsApp, YouTube, Telegram, TikTok, in another 5% of the papers mobile learning was studied. Only 2% of the studies used Virtual Reality (VR) or Augmented Reality (AR) and Videoconferencing tools such as Zoom, MS Teams, Skype, Facetime.

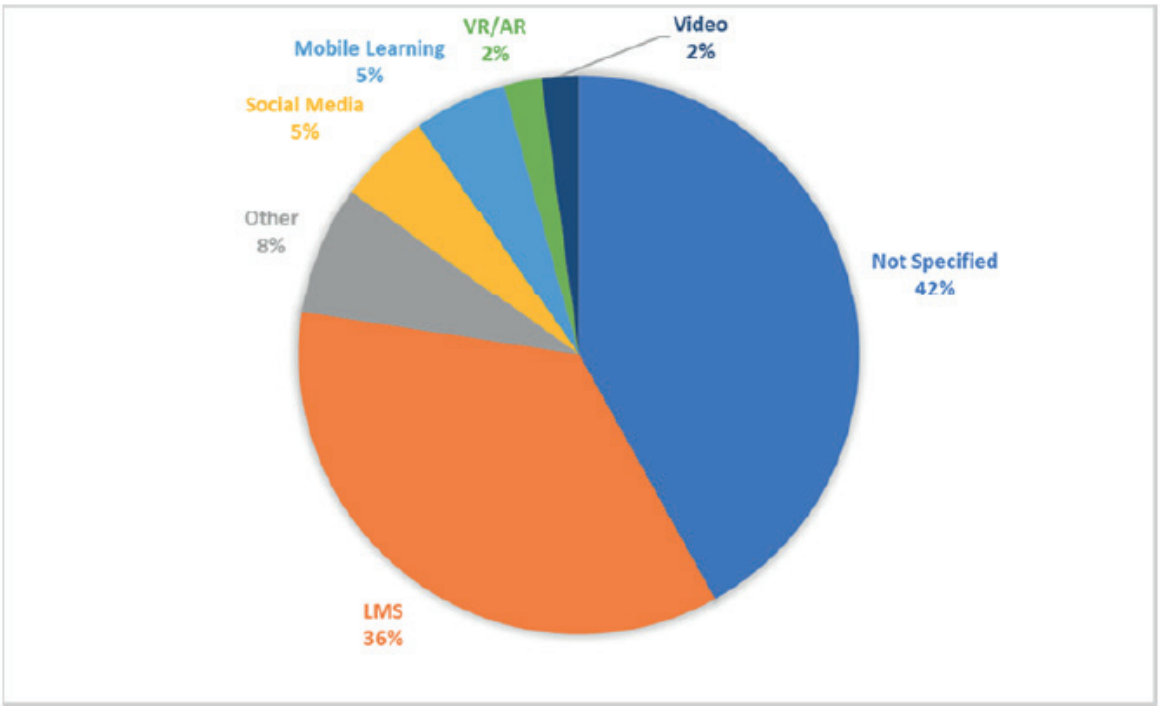

Figure 7. Distribution of the Reviewed Articles According to the Platforms, Technologies, and Software

Distribution of the Reviewed Articles according to Pedagogical Strategy

The most used pedagogical strategy was online only techniques (48%) such as interactive online lectures and recorded lectures (Figure 8). Pedagogical strategy was not mentioned in 32% of the papers. Blended learning strategies such as synchronous and asynchronous chat, discussion forum and flipped classroom were discussed in 17% of the papers. Only 1% of the papers focused on collaborative learning, while 2%

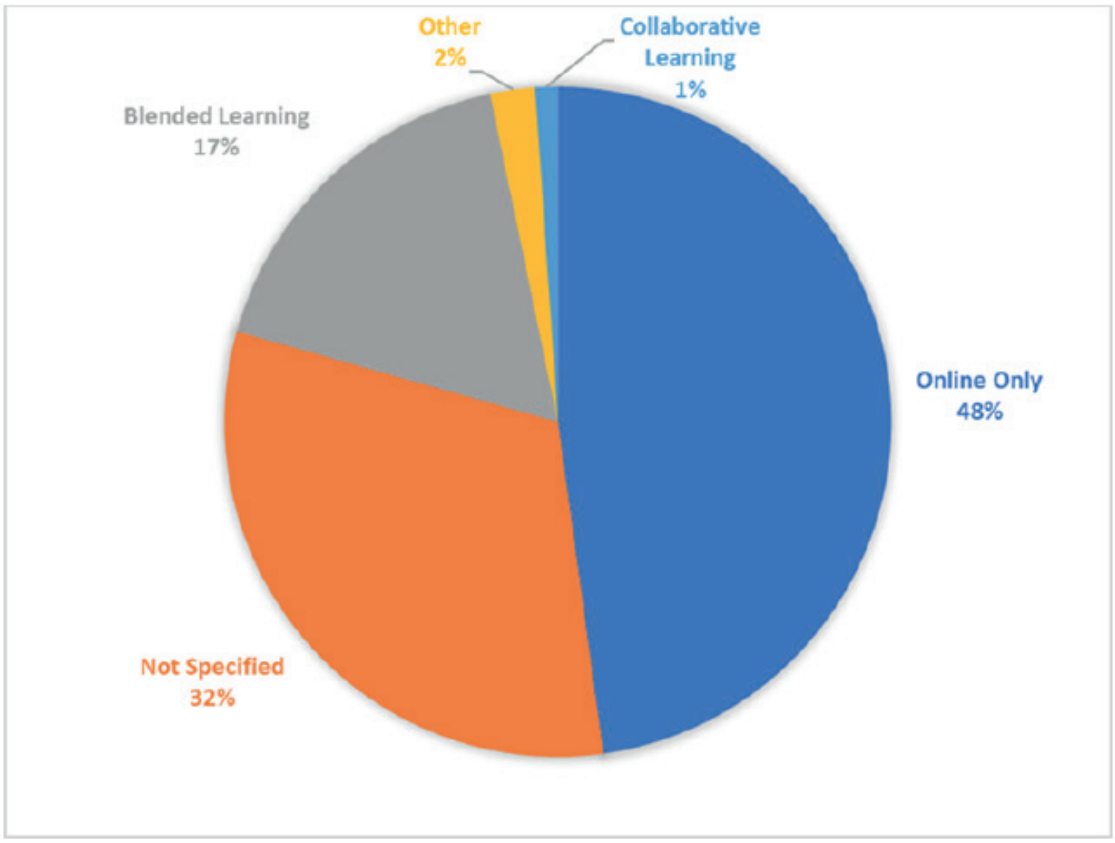

Figure 8. Distribution of the Reviewed Articles According to the Pedagogical Strategy

Emerging Types of Online Engagement

For this research question, indicators provided within the "Online Engagement Framework for Higher Education" suggested by Redmond and his colleagues (2018) were used as the criteria for exploring emerging types of online engagement. When the classification of article types according to engagement categories was completed, it revealed that the affective dimension of engagement (54%) was most studied dimension in the Turkish context followed by the behavioral dimension (32%) (Figure 9). Less research was encountered regarding cognitive (25%) and social (10%) dimensions, and unfortunately no research was conducted on the collaborative dimension. Since collaboration is the most important key factor for social and cognitive engagement, it was surprising that no researchers felt a need to investigate this construct.

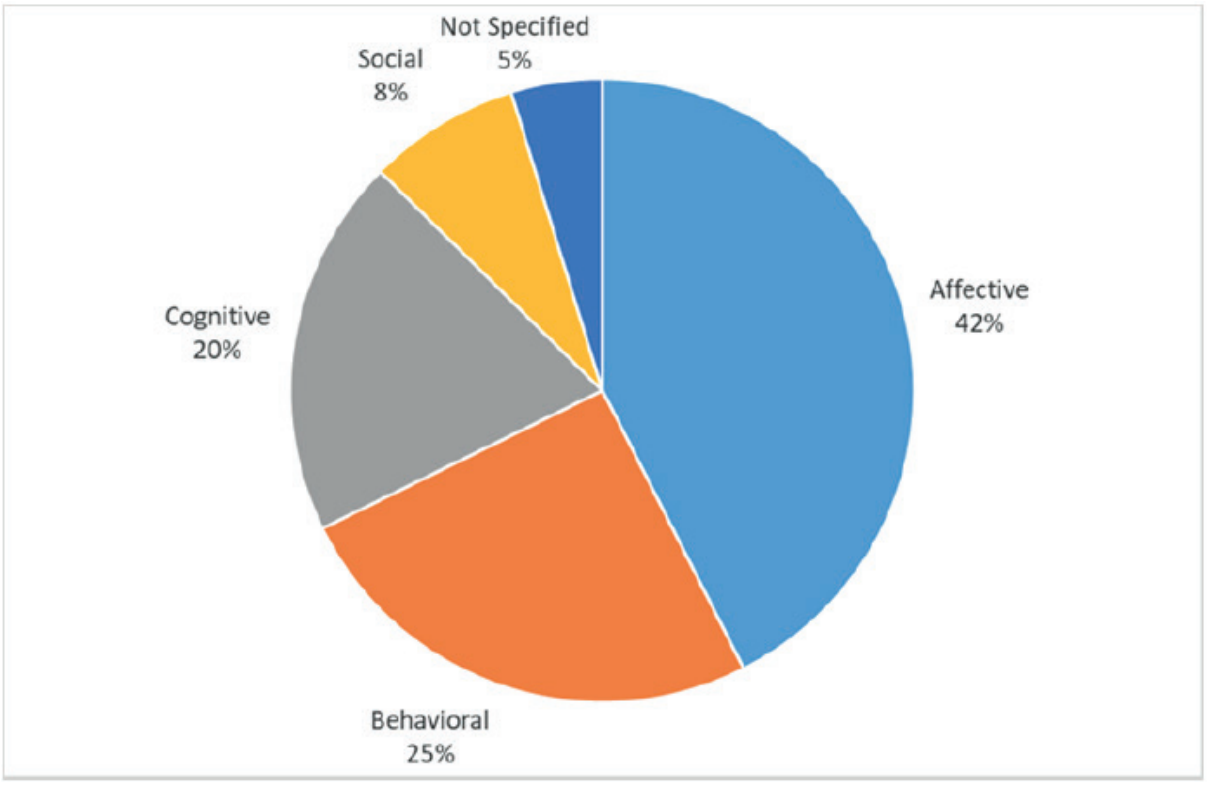

Figure 9. Emerging Types of Online Engagement

Emerging Themes Based on the Findings of the Reviewed Articles

An inductive analysis on the findings of studies was also carried to reveal the impact of the Turkish studies on the online learning engagement literature (Table 2). The most significant findings were that "learners' performance increased due to the use of digital technologies, materials and educational videos" where technologies mentioned for online learning were gamification, mobile technologies, social networks (N=25). Some studies revealed that learners' performance increased due to the use of digital platforms, i.e., engagement is affected and increased through the use of digital technology. In five studies mobile learning was specifically mentioned as a favored method for improving learners' performance. On this topic, one study reported that "students who use the gamified environment show higher participation" (Tunga & Inceoglu, 2020) whereas another reported "learners' performance increased due to augmented reality" (Koyun, Budak & Cankaya, 2018). Yet another study underlined that "blended learning enriched with different methods has a more positive effect on student achievement" (Cirak Kurt, Yildirim & Cucuk, 2018). A second emerging theme was that learners favored blended learning based on their perception of the advantages of online learning (N=13). The third emerging theme was the lack of social engagement in Turkish online learning and the ways to increase social presence (N=9). On this topic, one study reported that "not getting timely feedback negatively affects online engagement" (Elcil & Sahiner, 2014) whereas another focused on existing problems with online courses that are based on practice due to lack of expected engagement. Self-efficacy beliefs from a personal point of view and pedagogical concerns from an instructional design point of view were also mentioned in the reviewed articles as important factors that affect engagement (N=8). One study reported that "design of the teaching practice affects learner performance" (Eroglu & Kalayci, 2020) whereas another stated "use of different pedagogical approaches enhances learners' performance" (Horzum & Balta, 2008). In another study it is reported that "wrong pedagogical choices affect online engagement" (Elcil & Sahiner, 2014) and "inefficacy of management of online learning and digital materials" (Karadag & Yucel, 2020), which again refers to the instructional design point of view, underlining the importance of design for promoting engagement in online learning.

Some studies reported the effect of attitude, effort, and ability on engagement (N=8). One study reported that "affective variables can affect satisfaction of learners" (Eygu & Karaman, 2015) whereas in another

it is mentioned that the "nomophobia variable affects intrinsic motivation positively" (Bayram, Zeybek Yilmaz, Sozen & Bayer, 2019). Some studies investigated the e-learning readiness of learners and found lack of readiness to be high (N=6). However, this variable will likely decrease in relevance in the future because as virtually all students and instructors have been forced to learn and teach online, their readiness has had to increase.

Engagement in the articles reviewed was investigated in terms of relationships between social engagement–such as sense of class community–and cognitive engagement, and positive relationships are found between these confounding variables (N=4). Related to these arguments, one study reported that "as students' emotional and behavioral resistance levels increase, distance education is less instructive and their tendency to distance education decreases" (Genc, 2020).

Other important miscellaneous findings were identified. One article mentioned that "participation in online courses and monitoring of course video recordings at a later time enhances academic success" (Ergun & Kurnaz, 2019) and another that "participation in virtual classroom sessions can be improved through continuous information and guidance" (Kirmaci & Acar, 2018), highlighting the importance not only of engagement but also of as instructor involvement and instructional design.

Table 2. Emerging Themes Based on the Findings from the Articles

Theme	Frequency (N)
Engagement is affected and increased through the use of technology	25
Impact and advantages of blended learning	13
Lack of social engagement + ways to increase social presence	9
Self-efficacy beliefs	8
Effect of instructional design	8
Affective engagement	8
E-learning readiness	6
Relations between engagement types (social vs cognitive)	4

DISCUSSIONS AND CONCLUSION

In the recent past, the spread of the coronavirus (COVID-19) epidemic in the early 2020s caused a global emergency. With its unprecedented impact on higher education, the pandemic has limited education to online teaching and learning. This sudden shift showed how important the active participation of students in distance education and online engagement is (Dahleez et al., 2021). In this context, the purpose of this research was to systematically review the Turkish-language research on online engagement from 1995 - 2021 and uncover the pedagogical principles and methodologies that may be used to promote involvement in digital learning processes. In addition, this study was conducted to reveal the current situation regarding online student engagement research in the Turkish context, showcasing the research undertaken on this topic, especially the types of online engagement studied.

Through this systematic review, a final set of 90 topically relevant studies were identified, using the PRISMA method, a rigorous screening process. The first level of analysis was to examine research trend by year. It was evident that the number of papers concerning online engagement has increased yearly, likely the effect of a gradual increase in technology use in education in Turkiye. The publication of the Journal of Open Education Applications and Research (AUAd) and the acceptance of the Open and Distance Education discipline as an associate professorship field by the Interuniversity Board (Bozkurt, 2017) may account at least in part for the rapid shift in the number of papers published after 2016.

Considering the distribution of the reviewed articles according to the discipline, it was found that most of the studies were in the fields of computer science with 28%, folloed by educational sciences (18%) and language disciplines (10%). Given the increasing expansion of online computer science degrees including completely online university programs and MOOCs, it is not surprising that online engagement is the most studied topic in current research (Ruthotto et al., 2020). In this regard, it was interesting to note one study

that indicated that offering computer science-related courses in online format did not seem to negatively impact active participation of students when compared to face-to-face format (Basu, Heckman & Maher, 2021). Indeed, according to another study, the majority of students seem to prefer learning programming from the comfort of home (better computer and internet) to face-to-face education (Nguyen et al., 2018).

Examining the distribution of the reviewed articles according to the data collection type reveals that most of the studies were collected through quantitative methods (56%), while qualitative methods were used in 23% and mixed methods in 12% of the total papers. However, in another article which brings together distance education themed studies, qualitative methods are the most common. In fact, similar to our review, quantitative methods have been leading since 2020 (Siraz, 2021). The reason for this difference may be that the study mentioned above deals with a 3-year period starting from 2017. As a matter of fact, this study is a more comprehensive study covering a period of 12 years starting from 2008.

Considering the platforms where the studies were conducted, Learning Management Systems (LMSs) are the most used technology in the reviewed papers. This seems to be but one among many factors that enable students to engage in the online learning process. Another factor appears to be focusing on student performance by screening. Thus, embedded learning analytics tools seem to help identify students' needs, allowing the institution to map these needs to learning objectives (Ismail et al., 2021).

Considering the pedagogical strategies in the studies mentioned, online-only strategies were the most frequently encountered strategies for all the papers in total. Nevertheless, when compared to adopting an online-only delivery style, the blended delivery format appears to provide clearer instructions to learners consequently boosting their motivation, satisfaction, and engagement (Lim, Morris & Kupritz, 2007). In light of such earlier research, it was fully expected that the Turkish research would yield more articles where blended learning was adopted as a pedagogical strategy. However, one explanation for the preponderance of online-only strategies in the literature might be the perceived challenges that blended learning presents to instructors within the Turkish learning context: having to organize online and face-to-face activities, being more flexible, supporting interaction, tracking students not only online (it is easy to use learning analytics for online classes), but also face-to-face, and facing differences in student motivation in online and face-face instruction (Boelens, De Wever, & Voet, 2017).

The classification of article types according to engagement categories revealed that Turkish online engagement research is mainly focused on the affective/emotional dimensions of online engagement. This is not a surprising result since online engagement is defined as interaction between learners and content, and instructor and colleagues, through digital tools and environment. Collaborative engagement necessarily requires willingness and motivation to initiate collaborative activities as well as access to tools that can guarantee its success. Considering this difficulty, it comes as no surprise that the research encountered here focused first and foremost on individual properties related to engagement followed by the behavioral dimension as a second area of focus. Thus, our research has discovered a clear gap in the literature, that of collaborative engagement. As a result, it is recommended that, in order to keep learners' engagement continuous, educational researchers should turn their attention toward investigating the social dimensions by focusing on collaboration between learners in future studies (Martin & Bolliger, 2018).

This research also aimed at revealing important findings from the reviewed articles. The major finding was that "engagement is affected and increased through the use of technology" (Karakis, 2020; Koyun, Budak & Cankaya, 2018; Yilmaz, 2017) which underlines the importance of socialization and use of collaborative tools (Koranteng, Wiafe & Kuada, 2019). This finding is parallel with the second emerging fact that use of blended learning has an important impact on engagement in Turkish education since this approach is implemented through various online learning technologies. Thus, this third emerging finding further supports our hypothesis that there is an apparent lack of social engagement in online ecosystems and instructors need to look for ways to increase social presence (Seifert, 2016; Mebert, et. al., 2020).

In summary, highlights from current study are as follows:

1. The PRISMA approach was indeed a useful, systematic method for exploring online engagement literature in the Turkish context
2. As expected, the number of studies on online engagement has increased over the years; generally, computer science is the most represented, along with quantitative methods as the data collection type,

LMSs as platforms, and online-only techniques as a pedagogical strategy. In order to add diversity to the literature in future studies, online engagement studies can be directed to different fields other than computer science; qualitative methods can be emphasized; platforms such as social media and VR/AR can be used more frequently; and blended learning strategies can be adopted.

3. Although current Turkish research studies focused on affective behavioral dimensions of online engagement, more research is needed in the future about cognitive engagement, as well as social and collaborative engagement.
4. Engagement is mostly shaped around the use of technology, and that is why besides the affective, behavioral, and cognitive dimensions, future research should also address collaborative tools and the social dimension of engagement.

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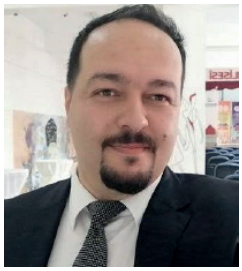

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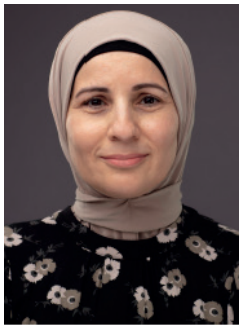

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APPENDIX

Search Strings

Base search strategy used in ERIC. All other databases using the same search with adjustments made for database search syntax requirements.

1 | ("Web 2.0" or "app based" or "asynchronous" or "augmented reality" or "blended learning" or "clicker assisted" or "collaborative online international" or "collaborative online learning" or "computer-assisted instruction" or "computer-assisted language learning" or "computer-based instruction" or "computer-based learning" or "computer-mediated learning" or "computer-supported collaborative learning" or "computer-supported cooperative learning" or "computer-supported cooperative work" or "computer-supported learning" or "computerized" or "cyber space" or "cyber-school*" or "Cyberspace" or "digital education" or "Digital Learning" or "distance education" or "distance eLearning" or "distance learning" or "distance teaching" or "e Learning" or "e-Education" or "e-Learning" or "e-universit*" or "Edtech" or "educational technolog*" or "Edutech" or "eLearning" or "gamification" or "gamified" or "interactive online" or "learning management system*" or "LMS" or "long distance learning" or "long distance teaching" or "massive open online course*" or "mobile learning" or "MOOC" or "online collaborative learning" or "online course*" or "online education" or "online education" or "online instruction" or "online learning" or "online teaching" or "online universit*" or "online workshop*" or "personal learning environment*" or "remote instruction" or "remote learning" or "remote teaching" or "smart phone app*" or "smartphone app*" or "social network*" or "SRS" or "student response system*" or "technology enhanced learning" or "technology mediated" or "technology-enhanced" or "technology-mediated" or "user generated content" or "virtual classroom*" or "virtual learning" or "virtual learning environment*" or "virtual reality" or "virtual teaching" or "web based seminar*" or "web conferenc*" or "web course*" or "web-based instruction" or "web-based training" or "web-enhanced instruction" or "web-enhanced learning").tw.

2 | (Blended Learning or Computer Mediated Communication or Educational Technology or Technology Uses in Education or Online Courses or Electronic Learning or Instructional Innovation or Technology Integration or Social Networks or Internet or Handheld Devices or "Web 2.0 Technologies" or Social Media or Computer Assisted Instruction or Computer Assisted Testing).sh.

3 | (college* or universit* or graduate or undergrad* or seminary or higher education or technical or vocational or college prep* or informal learning or formal learning or lifelong learning or continuing education or adult education or Tertiary education or post secondary education or postgrad* or student or pupil).tw.

4 | (Colleges or Universities or Graduate Students or Undergraduate Students or Higher Education or Lifelong Learning or Postsecondary Education).sh.

5 | (Algeria or Algerian* or Bahrain or Bahraini* or Egypt or Egyptian* or Iran or Irani* or Iranian* or Iraq or Iraqi* or Israel or Israeli* or Jordan or Jordanian* or Kuwait or Kuwaiti* or Lebanon or Lebanese or Libya or Libyan* or Morocco or Moroccan* or Oman or Omani* or Palestine or Palestinian* or "West Bank" or Gaza or Gazan* or Qatar or Qatari* or "Saudi Arabia" or Saudi* or Syria or Syrian* or Tunisia or Tunisian* or Turkiye or Turkish or Turks or "United Arab Emirates" or Emirati* or Yemen or Yemeni* or MENA or "Middle East" or "North Africa" or "North African" or "Arabian Gulf" or "Middle Eastern" or Arabian).ti,ab.

6 | #1 OR #2

7 | #3 OR #4

8 | #6 AND #7 AND #5

9 | #8 Limited to 1995 to Current

ACADEMIC DISHONESTY IN DISTANCE EDUCATION COURSES: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT

This research study focuses on the growing concern of academic misconduct in distance education courses. A quasi-experimental study was conducted to measure the impact of introducing webcam recording software as an online supervision tool for high-stakes exams in two separate online courses (Management and Accounting). Results revealed that overall performance decreased following implementation of the software, and persisted after taking potential confounding factors into account. Additionally, the explanatory power of the regression analysis was higher for scores under supervision, which suggests that cheating was occurring before online supervision was introduced. It can be concluded from this study that online supervision is an effective tool to combat academic dishonesty in distance education courses.

Keywords: Distance education, remote learning, cheating, academic dishonesty.

INTRODUCTION

In recent years, distance learning has seen a tremendous rise (Mittelmeier et al., 2021). A lot of "conventional" universities now offer online courses or even full online degree plans because there is a continuous need for them (Pregowska et al., 2021). Educators in all kinds of institutions understand that an essential change has occurred, and that digital teaching and learning will play an integral role in postsecondary education in the years to come (Bozkurt & Sharma, 2020). Especially due to COVID, many educational institutions had to transition to virtual learning, making distance learning more accessible than ever before (Al Lily et al., 2020).

Rumble (2019) in his book explain the various aspects of distance education. According to him, distance learning often involves students accessing course materials online such as lectures, readings, quizzes and exams. It is also possible for learners to communicate with professors directly via email or through discussion boards and chats. Often it also includes the use of synchronous tools such as video conferencing and virtual classrooms for students to interact in real-time. Distance learning enables students from all over the world to access high-quality education and provides great flexibility with regards to when, where, and how they study. This makes it possible for people who are not able to attend traditional universities or colleges due to geographical constraints or financial issues, to still access a quality education.

Therefore, the debate around distance education has shifted to how best to provide online courses (Castro & Tumibay, 2021). Different elements of remote learning such as mode (fully digital or hybrid; synchronous or asynchronous) (Moorhouse & Wong, 2022), technology platform (W. Ali, 2020), assessment (Guangul et al., 2020) and access (W. Ali, 2020) are being discussed and assessed. Ultimately, the objective of this

exchange is to develop and deliver distant courses that provide students with a learning experience that at least equals that of traditional Face-to-Face (F2F) courses. As a result, the issue of how much learning takes place in distant courses compared to F2F is becoming an increasingly important point of discussion.

Questions concerning the validity of scores in distance education courses versus F2F courses often arise due to the potential for increased academic dishonesty when it comes to assessments (Elsalem et al., 2021). It is assumed that cheating may be more prevalent in distance learning compared to traditional setting (Kamble & Ghorpade, 2021). Therefore, if exam score distributions are comparable in distant education courses to a face-to-face one, it does not necessarily mean that similar levels of learning have taken place due to the possibility that the scores in the distant course may have been inflated by cheating.

Arguments have been put forward that suggest distance learning could be more prone to academic misconduct (Khan et al., 2022). This is due to the fact that it can be difficult to verify who is completing assessments in an unsupervised setting and people may use external sources of information, such as cheat sheets and online materials, when taking tests. Additionally, the lack of physical contact with a teacher may create an opportunity for collective work between students.

Despite there being evidence regarding academic dishonesty in distance learning, debate over the issue remains unresolved. This study presents evidence from a quasi-experimentation conducted in two distant education courses at a virtual university in Pakistan, where high-stakes exams were supervised using webcam recording software. As the structure and content of each course remained the same before and after the introduction of online supervision, any changes noticed in student performance can be attributed to the reduced incidence of cheating. This provides direct evidence on the extent of academic dishonesty in distance education courses.

This study is unique in comparison to existing literature since it does not involve a modality change for supervision. Previous studies have compared student performance between unsupervised online assessments and supervised F2F tests (I. Ali et al., 2022; Leong et al., 2022), however this can lead to discrepancies regarding the impact of the testing environment versus supervision itself (Crawford et al., 2020). By assessing performance in the same mode (online) with and without supervision, this avoids such issues. From a practical standpoint, in-person supervision of tests may not be feasible for fully online courses, so the results here provide evidence on how useful low-cost remote supervision is for distance education programs.

The research findings demonstrate that cheating was occurring in unmonitored exams. Analysis of the data revealed a noticeable decline in average test scores after online supervision was enacted, frequently by more than one grade. This drop held even when student characteristics were similar pre and post-supervision, suggesting selection bias was not at play. Furthermore, the results from a multiple regression analysis could not be used to explain away the decrease in marks. Lastly, when comparing the explanatory power of regressions based on student ability and maturity indicators, it was found that supervised exams had higher scores. This implies that online monitoring is an effective approach for abating cheating in distance learning courses.

LITERATURE REVIEW

Academic Dishonesty

Davis et al. (1992) has explained academic dishonesty as any type of cheating that occurs in relation to a formal academic exercise. It can include plagiarism, the fabrication of information or citations, collusion with others on assignments, knowingly using unauthorized materials during an exam and/or attempting to gain unfair advantage by misrepresenting facts relating to an academic exercise. McCabe & Trevino (1993) emphasize that academic dishonesty not only undermines the integrity of a course and the institution, but it also violates the principles of academic honesty.

Students may engage in academic dishonesty for a variety of reasons. Some students feel pressure to succeed and to get the highest grades possible (Krou et al., 2021), leading them to use dishonest tactics as a way to "ensure" success. Some students simply do not understand the rules and regulations around academic honesty (Yang et al., 2013). McCabe et al. (2001) suggest that a variety of reasons contribute to academic dishonesty, including insufficient preparation or interest, pressure to succeed, misunderstanding rules or

expectations surrounding cheating, thinking others are behaving similarly, and feeling there will be no major repercussions if one is caught. The type of dishonesty – whether it's spontaneous or premeditated – also affects which of these factors come into play.

Becker et al. (2006) suggested that academic dishonesty is a result of three major elements: incentives, opportunities and rationalization. Incentives refer to both internal and external pressures driving the student to cheat; opportunity pertains to an environment that enables cheating; while rationalization allows the individual to justify their actions as not being in violation of their beliefs or ethics. These components together form a type of fraud triangle which is used to investigate fraudulent behavior in various business contexts.

Research has looked into the impact of certain personality traits on cheating, such as the Big Five factors (neuroticism, extraversion, openness to experience, agreeableness and conscientiousness) (Giluk & Postlethwaite, 2015). Additionally, the Theory of Planned Behavior has been used to look into how beliefs surrounding anticipated outcomes, reference individuals or groups, and challenge/obstacles affect the intention to cheat and cheating behavior (Harding et al., 2007). Research has demonstrated that economic, interpersonal, and individual factors all contribute to academic dishonesty (Eshet et al., 2021). Becker et al. (2006) discovered that students under greater amounts of stress or pressure from external sources are more prone to cheating. In contrast, Day et al. (2011) found that when teaching fosters learning over competition and grades, the incentive to cheat is reduced. Lastly, Pulfrey et al. (2019) revealed that emphasizing mastery-based learning and providing autonomy can reduce instances of cheating in the classroom.

Studies have highlighted the importance of honor codes and faculty/institutional efforts in reducing the prevalence of academic misconduct (Raman & Ramlogan, 2020). A lack of well-defined rules, expectations and sanctions can result in an environment that encourages dishonesty. Thus, it is necessary to inform students about the principles of academic integrity and make sure that these are being enforced by having clear consequences for rule-breaking.

Impulsivity and a strong need for sensation may be linked to more tolerant views towards cheating, as well as an increased tendency to do it (Smith et al., 2021). On the other hand, traits such as prudence, self-control, and purpose that relate to conscientiousness might lead people to think of cheating as unacceptable and less likely to commit acts of academic dishonesty (Steinberger et al., 2021). A meta-analysis by Giluk & Postlethwaite (2015) found that two major factors were related to academic dishonesty: agreeableness and conscientiousness, with both of them having a negative effect on it.

Furthermore, research examining academic dishonesty in higher education reveals that social norms and culture can play a role. Chudzicka-Czupała et al. (2016) found that moral obligation is a key factor in predicting intention to cheat among university students across seven countries. Additionally, Orosz et al. (2013) determined that feelings of guilt and shame had a strong influence on academic dishonesty. Furthermore, Maloshonok & Shmeleva (2019) found that subjective norms - specifically, how students perceive the cheating behavior of their peers – are more influential in collectivist cultures like Russia than own beliefs. Thus, social/- subjective norms often override individual beliefs when determining involvement in academic dishonesty.

Research into the relationship between academic misconduct and student demographics, characteristics and behaviour patterns has not produced clear results (Lofstrom et al., 2015). Generally, younger students (such as freshmen) and males appear to be more likely to engage in cheating (Bertram Gallant et al., 2015); however, some research has found no effect or even an inverse relationship (Isakov & Tripathy, 2017). Lack of preparation time, lower grades, and alcohol use have all been linked to higher rates of cheating (Korn & Davidovitch, 2016). Studies have also suggested that certain academic disciplines (such as engineering and business) tend to have a higher rate of academic dishonesty, though other studies have disagreed with this position (Ramberg & Modin, 2019). Additionally, prior experience with cheating, risk-taking behavior and an emphasis on personal values (e.g. pleasure-seeking or power) can also increase the likelihood of cheating while in college (Orosz et al., 2016).

Academic Dishonesty in Online Courses

Studies examining self-reported acts of cheating have yielded mixed results. Some studies indicated that the same level of academic dishonesty existed in both live and virtual courses (Gamage et al., 2020; Hylton et al., 2016). Conversely, other research showed higher levels of cheating among online students (Corrigan-Gibbs et al., 2015; Nguyen et al., 2020). Additionally, some studies found that self-reported academic dishonesty was higher in traditional courses (D'Souza & Siegfeldt, 2017).

It has been suggested that traditional courses may be more prone to academic dishonesty due to the close social connections formed amongst students, which encourage peer pressure and collusion (Zhang & Yin, 2020). Additionally, studies indicate that those taking entirely online courses tend to be more mature and motivated than those taking both online and traditional courses, leading to lower levels of cheating being reported (Kidwell & Kent, 2008). Furthermore, Sendag et al. (2012) found that those taking entirely traditional courses were more likely to be involved in e-dishonesty compared to those enrolled in at least one hybrid or online course.

Recent surveys indicate that academic misconduct is more prevalent in online classes than in face-to-face ones (Chiang et al., 2022). Research across different disciplines shows engineering students tend to cheat more often, a tendency which may be amplified in virtual settings (Chirikov et al., 2020). Business students also perceive higher rates of cheating in the digital environment (Lord Ferguson et al., 2022). Harton et al. (2019) conducted a study and the majority of those surveyed from multiple fields at one public university view cheating and plagiarism as greater issues in the online environment. However, according to a study from Peled et al. (2019) in six US and Israeli schools, students were less likely to participate in unethical academic practices in online courses than traditional ones.

Academic Dishonesty in Supervised vs Unsupervised Exams

Research has indicated that supervision is deemed crucial in the realm of exams. Noorbehbahani et al. (2022) found that cheating was far more common in unsupervised online tests than those which were remotely monitored. Holden et al. (2021) surveyed engineering students from four universities and their results showed that students believed cheating was more permissible in an unsupervised setting. Research has revealed that cheating is a major issue in unsupervised testing environments. Harmon & Lambrinos (2008) compared the explanatory power of supervised exam scores to those taken without supervision, and found that supervised exams had higher explanatory power, indicating that cheating was likely taking place in the unsupervised tests. Arnold (2016) conducted a similar study with a large economics class, finding that student performance on supervised formative tests was more closely associated with student characteristics than unsupervised tests, suggesting cheating also took place in the latter. However, these results were not as strong as Harmon & Lambrinos's findings.

In cases where there is no obvious evidence of poorer performance in a supervised settings, other factors may lead to doubts about unsupervised circumstances. Hylton et al. (2016) compared the online exams of two different groups, one supervised by a web-based proctor and the other not monitored. Although their performance was similar, those in the unsupervised group spent more time on tests. Holden et al. (2021) had comparable findings when looking at scores from three groups of students: those taking the online unsupervised exams, onsite supervised ones, and online supervised using remote software. The results showed that although there was no significant difference in terms of performance, the unsupervised group took longer time during tests which could suggest they were attempting to look up answers. Furthermore, Golden & Kohlbeck (2020) compared the results of those who had to answer verbatim test questions with those of students asked reworded queries. Those taking the pre-set inquiries attained higher marks (by 11 percent), revealing that many were likely searching for answers on the web. The gap between the two groups was reduced when monitoring software was employed, demonstrating that this technique contains some cheating.

METHOD

This research was conducted in two online courses at one of Pakistan's largest distance education universities. The courses were Principles of Management and Principles of Accounting. Both classes had been running for some time and were taught by experienced lecturers in a fully asynchronous online environment. This study focuses on nine sections of Principles of Management (offered between Spring 2020 and Spring 2022) and ten sections of Principles of Accounting (offered between Fall 2020 and Spring 2022). The course structures, contents and exams remained consistent during the given period; however, major changes came in Spring 2021 when online supervision was introduced through a webcam recording software. This altered the way high-stakes assessments were conducted in both courses.

Prior to Spring 2021, exams in each course were composed of multiple-choice questions and would make up 45 to 70 percent of the course grade. These tests focused on one-third of the total course material, but were not cumulatively assessed. To discourage cheating, special measures were adopted such as a specific browser being used while taking the test, randomizing the order of questions and options, limiting the time in which students had to take it, and setting a time limit on its completion.

Beginning in spring 2021, the implementation of monitoring software has enabled direct observation of students during their exams, which are given in an online environment. This process includes instructions for the student along with a photograph and video recording to verify identity and surroundings. The software will then record the student throughout their test period, after which instructors will have access to the recording, as well as random screenshots. The program also provides a report to the instructor of any uncommon occurrences (e.g. reduced visibility or face recognition) and when these incidents happened.

This study utilizes two types of data. Exam scores were gathered from the instructor's records, while student demographic and academic background variables were obtained from the university's institutional research office. The additional information was collected to determine whether there was any observable change in student composition related to the introduction of online supervision, as well as for use as explanatory variables in regressions of student performance.

The literature has suggested that a student's aptitude, gender and maturation are potential factors for performance in college courses. GPA is used to indicate a student's capability (Grove et al., 2006). To evaluate this, the incoming GPA before the start of the semester was used. If this isn't available, the final semester GPA excluding the grade of the course being studied was used. Age and amount of college credit hours obtained before enrolling in the class were both utilized to determine a student's maturity, which has been associated with reduced cases of academic dishonesty.

FINDINGS

Tables 1 and 2 show descriptive details of the sample studied. The inclusion criterion was that students had to remain in the course until it concluded (i.e., they must have taken all three exams). When observations with missing information on key variables were removed, the sample size totalled 594 students (240 in Management and 354 in Accounting). The stats are organized by course and supervision status (i.e pre-supervision/spring 2021 post-supervision/spring 2021). A test of means equality is included to determine if there was a noticeable difference in sample composition following the implementation of online supervision.

Table 1 illustrates that the sample size in management who took their course under online supervision was composed of fewer females, a younger age group, and individuals with less academic experience. However, these differences were not statistically significant. The only statistically significant distinction between the two groups was that the average GPA for those who took their course under online supervision was lower than that of the pre-supervision sample ($t = 2.19$, p-value = .03). The results of the accounting course (as seen in Table 2) did not show any significant differences between samples with and without supervision when looking at gender proportion among students or average GPA. However, the sample group that completed the post-supervision exam was younger on average ($t = 1.90$, p-value = .06) and had 7 fewer accumulated credit hours at the start of the course ($t = 2.50$, p-value = .01).

This research is looking for dependable proof of academic cheating in online learning which transcends educational disciplines, so data from two distinct courses is being used. The majority of previously conducted

performance-based studies had results that were limited to a single area of study (or college/department) or group. The courses utilized in this inquiry are derived from two different educational streams of the university. Additionally, as Tables 1 and 2 demonstrate, despite both classes being classified as-level (for sophomores), there are clear disparities in the student profiles. Compared to the management course, the accounting class is more likely to be populated with female students, who tend to be older, more experienced (as juniors instead of sophomores) and have a higher aptitude.

Table 1. Student Characteristics (Management)

	Unsupervised			Supervised			t	P > t
	Mean	Standard Deviation	N	Mean	Standard Deviation	N		
Female	.40	.50	155	.30	.50	85	.79	.40
Age	20.50	2.10	155	20.00	1.45	85	1.10	.30
GPA	2.90	.65	155	2.69	.65	85	2.19	.03
Credit Hours	49.50	31.25	155	47.85	26.80	85	.89	.40

Table 2. Student Characteristics (Accounting)

	Unsupervised			Supervised			t	P > t
	Mean	Standard Deviation	N	Mean	Standard Deviation	N		
Female	.55	.49	231	.59	.49	123	.65	.49
Age	21.38	3.09	231	20.80	3.80	123	1.90	.06
GPA	2.90	.65	231	2.90	2.90	123	.16	.90
Credit Hours	76.80	34.00	231	69.50	34.59	123	2.50	.01

Bivariate Analysis

Tables 3 and 4 demonstrate the influence of online supervision on student performance in management and accounting courses. The tables illustrate student scores with and without supervising for each exam, allowing one to determine if cheating was occurring in the absence of supervision, as well as how effective online supervision is. The results indicate that when supervision was introduced, the performance of students in all exams decreased significantly. The median score dropped considerably, sometimes as much as over 30 percentage points, and the variability (dispersion) of scores increased due to a noticeable decrease in lower-scoring individuals.

Table 3. Score Summary (Management)

	Unsupervised			Supervised		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Exam 1	80	42	94	63	26	85
Exam 2	84	56	100	58	24	94
Exam 3	79	45	96	56	22	85

Table 4. Score Summary (Accounting)

	Unsupervised			Supervised		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Exam 1	80	68	88	75	63	81
Exam 2	84	75	93	71	62	78
Exam 3	93	84	98	77	64	82

Tables 5 and 6 show the average results and standard deviations on tests in management and accounting, respectively, with supervision. The evidence indicates that performance was significantly lower under supervision, with mean scores decreasing by between 10-20 percentage points in both courses. The greatest difference of 18.6 percentage points was seen in management, while the average difference in accounting was 13.5 percentage points - all differences being statistically significant.

The significant shift in the score distributions and the substantial decrease in average results point to the fact that cheating was likely widespread before online supervision was implemented. This goes to show that online supervision is a viable means of preventing cheating during high-stakes tests.

The changes in the score distributions and the decrease in average performance demonstrate that academic dishonesty may have been a frequent occurrence before online supervision was implemented. This implies that using online supervision has been successful in reducing cheating during significant tests. The ANOVA results strongly imply this; however, the upcoming subsection will utilize multiple regression-based analysis to further explore academic dishonesty in the courses.

Table 5. Exam Scores (Management)

	Unsupervised			Supervised			t	P > t
	Mean	Standard Deviation	N	Mean	Standard Deviation	N		
Exam 1	80	12.03	155	63	14.39	85	7.19	.00
Exam 2	84	12.40	155	58	16.81	85	10.05	.00
Exam 3	79	14.51	155	56	16.84	85	9.87	.00

Table 6. Exam Scores (Accounting)

	Unsupervised			Supervised			t	P > t
	Mean	Standard Deviation	N	Mean	Standard Deviation	N		
Exam 1	80	10.70	231	75	12.90	123	8.21	.00
Exam 2	84	11.19	231	71	13.19	123	12.29	.00
Exam 3	93	9.79	231	77	13.39	123	13.59	.00

Regression Analysis

In this paper, the regression methodology of Harmon & Lambrinos (2008) is adopted to investigate academic dishonesty among online students, as also used by Beck (2014) and Arnold (2016)this raises the issue of academic dishonesty. In the literature, a debate is waged on the prevalence of cheating in unproctored online environments. The issue is whether online exams are invitations to cheat. We add to this literature by using the Harmon & Lambrinos (2008. The model examines how test scores are affected by human capital and other student characteristics such as gender, age, class rank etc. In the context of this paper, "human capital" refers to the skills, knowledge, education, and other attributes possessed by students that contribute

to their ability to perform well academically. It looks at the impact of these variables on supervised and unsupervised tests separately, with Harmon and Lambrinos (2008) arguing that human capital should have a more pronounced effect on the former than the latter due to the presence of cheating in unsupervised settings. The R^2 statistic is employed to compare the explanatory power of both types of tests. In study, different combinations of student characteristics were used to calculate baseline regressions. Ultimately, it was determined that the only significant factors influencing performance were a student's GPA and age, while sex and credit hours earned had little-to-no effect on results.

The Goldfeld-Quandt test, developed to identify heteroscedasticity, is employed by Harmon and Lambrinos (2008) and Arnold (2016) to compare the regression results between the two conditions (with and without supervision). The aim of this comparison is to establish whether cheating occurs more often when supervision is absent, by examining if the error variances and R^2 in each of the models are significantly different.

The Chow test is utilized to analyze if the effects of human capital and age on performance have changed with the implementation of online supervision. This test checks if three variables (b0, b1, and b2) are equal to corresponding values (a0, a1, and a2) as outlined by Wooldridge (2008). The hypothesis is that if cheating took place before the supervision was introduced, then this test would be able to detect a shift in the relationship between human capital (demographics?) and exam performance as well as an increased impact of the former on the latter.

RESULTS

The data in Table 7 shows that GPA was a very significant factor in exam performance both when supervision was and was not employed. A one-unit increase in GPA on average raised the score of an unsupervised exam by half a letter grade (5 percentage points). This effect became even more pronounced with supervision, where an increase of one unit in GPA translated to an 8-percentage-point increase in exam scores.. As such, supervision allowed human capital and maturity factors to play a more influential role in determining outcomes on exams. Additionally, age had a positive effect on performance only when supervision was involved. It is thus likely that online supervision reduces cheating and allows for more accurate results.

The results of a pairwise test using the Goldfeld-Quandt method indicated that there was a statistically significant difference in error variances between supervised and unsupervised exams for Exam 2, but not for Exams 3 or the average score (p values just outside of 0.05). The Chow Test revealed that the estimated coefficients in the supervised regression were significantly different from those in the unsupervised regression ($p < 0.05$). This suggests that there is a structural break between the two forms of exams. The results in Table 3b regarding accounting show that higher grades are linked to improved performance with and without supervision. The impact of a one-unit increase in GPA is more noticeable when there is supervision, comparable to the data from management exams (where it is around half or three-quarters of a letter grade). Interestingly, age is found to be a factor in unsupervised exams, where older students tend to perform better than younger ones when controlling for ability.

The results of the regressions suggest that cheating may have been occurring in the accounting course before online supervision was introduced. The Goldfeld-Quandt and Chow tests both revealed significant F-statistics at 1% levels, meaning the estimated coefficients between pre- and post-supervision were significantly different. This implies that cheating may have been taking place.

Table 7 a. Regression, Management (Unsupervised)

	Exam 1	Exam 2	Exam 3	Average
GPA	5.670 *** (3.49)	5.256 *** (3.20)	4.819** (2.39)	5.250***(3.65)
Age	-.029 (.06)	-.649 (1.29)	.169 (.30)	-.170 (.40)
Constant	62.834 *** (5.70)	80.889 ***(7.20)	57.479 *** (4.25)	67.070***(6.79)
R^2	.089	.090	.041	.095
N	155	155	155	155

Table 7 b. Regression, Management (Supervised)

	Exam 1	Exam 2	Exam 3	Average
GPA	10.570 *** (3.49)	7.249 *** (2.60)	5.780** (2.00)	7.829***(3.80)
Age	2.340 ** (2.30)	2.680** (2.04)	2.950** (2.25)	2.651*** (2.80)
Constant	-9.739 (.45)	-10.459 (.39)	-21.149 (.75)	-13.781 (.70)
R^2	.263	.120	.099	.215
N	85	85	85	85
GQ Test F (71,129)	1.17	1.79***	1.30	1.30
Chow Test F (3,201)	17.59***	34.19***	30.74***	41.89***

Table 8 a. Regression, Accounting (Unsupervised)

	Exam 1	Exam 2	Exam 3	Average
GPA	5.630 *** (6.00)	4.760 *** (4.80)	3.226*** (3.59)	4.538***(6.01)
Age	.380** (1.99)	.475**(2.37)	.090 (.50)	.310** (2.05)
Constant	57.234*** (12.40)	60.790***(12.29)	77.665*** (17.35)	65.229***(17.46)
R^2	.135	.098	.046	.131
N	231	231	231	231

Table 8 b. Regression, Accounting (Supervised)

	Exam 1	Exam 2	Exam 3	Average
GPA	8.851 *** (5.70)	7.300 *** (4.40)	7.069*** (4.20)	7.740***(6.01)
Age	.091 (.34)	-.051 (.20)	-.244 (.90)	-.070 (.30)
Constant	44.502*** (6.10)	49.860***(6.40)	58.270***(7.40)	50.879***(8.40)
R^2	.180	.115	.115	.200
N	123	123	123	123
GQ Test F (149,286)	1.40***	1.40***	1.75***	1.45***
Chow Test F (3,435)	27.21***	56.60***	68.69***	78.26***

DISCUSSIONS AND CONCLUSION

As the use of remote learning accelerates across universities and colleges, administrators and educators are endeavouring to handle various matters related to it such as its quality, level of participation, fairness, availability, and legitimacy. Ultimately, they want to keep refining these elements in order to make sure that all relevant people - students, faculty members, and institutions - are happy with the teaching and learning they receive.

This paper has provided new information on one element of distance learning to improve it: academic honesty in online classes. Past research was not clear about how much cheating took place, however more

recent studies have suggested it is widespread (Golden & Kohlbeck, 2020; Norris, 2019). Compared to existing literature, this study offers several advantages. It includes two courses from the same university, making it unlikely that results are due to discipline-specific characteristics. Additionally, data was collected across multiple semesters which shows that the findings are reliable and not just a representation of one moment in time.

In order to analyse cheating, the research took advantage of a quasi-experimental design where online supervision was implemented at a certain point during the investigation. This allowed for an assessment of how performance changed before and after supervision, since there were no significant alterations in course structure, content or format. Additionally, demographic and academic data was taken into account to illustrate that there were no significant modifications in the sample size due to supervision, which would have impacted the results. This also addressed a criticism in other studies where it was difficult to distinguish between effects of supervision and assessment environment, due to comparing performance in unsupervision online tests with those done in person (Fask et al., 2014). These types of studies were also more susceptible to selection bias.

The findings of the analysis clearly point to cheating before online supervision was implemented. All exams administered in the two courses had significantly lower scores when supervised, and regression exercises demonstrated that GPA had a larger influence on scores for monitored exams than those without monitoring. These results were corroborated by various statistical tests, showing a shift in coefficient estimates and greater explanatory power for tests with supervision.

The investigation ascertained that academic deceit is a genuine concern in online courses, even with the implementation of countermeasures such as a specialized browser, limited testing period, randomized queries and answers, and a strict timer. The results further showed that cheating was rewarded with improved test scores. These findings suggest that direct supervision is likely the most effective way to shield against cheating during important online tests, with other deterrents working best as supplementary methods.

Another crucial aspect to consider is that supervision should not necessarily be implemented in a live or in-person setting for it to be an effective deterrent of academic dishonesty. Often, traditional supervision involves overseeing exams with the assistance of an instructor or delegate either on campus or at a testing center, or through remote monitoring. Unfortunately, this type of supervising is often too costly or simply not feasible for students studying online. The expenses and inconvenience associated with live supervision can thus discourage potential students from pursuing online education, as well as instructors and educational institutions that may otherwise have explored distance learning but think it lacks integrity without supervised assessments.

The findings of this research suggest that an online monitoring system, which uses webcam recording software, can effectively reduce instances of academic dishonesty. This solution is not foolproof, and neither is traditional in-person monitoring; however, its affordability and user-friendliness make it a viable option for faculty and universities looking to prevent cheating. These results should be seen as encouraging for all stakeholders.

Limitations

A few potential issues and areas for further research need to be addressed in relation to this study. It is possible that some of the decreased performance observed under supervision could be a result of increased tension or stress experienced by students when being recorded during an exam (Crawford et al., 2020). However, as current students are very familiar with technology, this impact could be minor. Additionally, the educators did not receive any responses indicating that the majority of students were anxious about the process.

This study has certain desirable features, yet there are a few limitations as well. It is possible that the student populations before and after supervision may have differed systematically in ways not taken into account by our regressions. Furthermore, it is not possible to draw direct conclusions about the effectiveness of online supervision compared to F2F supervision from this study. In order to make more general inferences, a truly experimental design with control and treatment groups should be utilized alongside a DiD analysis. Additionally, it would be interesting to observe the effects of web-based supervision over an extended period, as students become more familiar with the system and possibly modify their behavior accordingly

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LEARNING ANALYTICS FOR PERSONAL LEARNING ENVIRONMENTS: DETERMINING JOURNAL PUBLICATION TRENDS

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ABSTRACT

The e-learning domain has witnessed a shift from the traditional behavioral approach to an individual-centered learning approach based on learning analytics, with the aim of creating personalized and learner-sensitive designs. A systematic literature review of 284 articles published between 2011 and 2022 in 133 different journals was conducted to investigate this trend. Bibliometric analyses were performed. The results of the analysis show that there is an increasing trend towards the implementation of learning analytics and the use of these analytics for personalized learning environments. The results also show that the output levels of learning analytics have progressed from description and diagnosis to prediction and perspective building. This has the potential to improve the fields of learning analytics and personal learning environments.

Keywords: Learning analytics, personal learning environments, bibliometric analyze, learning design.

INTRODUCTION

Learning is a unique process that takes place as individuals perform certain activities at many different stages. This uniqueness brings with it the need to personalize learning and organize it by considering individual needs and goals (Firat, 2015). Learners attach great importance to personalized learning to recognize their own processes and competencies and to obtain more information (Kleimola & Leppisaari, 2022). In this regard, learning analytics is a crucial opportunity to individualize teaching in line with data obtained by analyzing learner behaviors (Zilinskiene, 2022).

In recent years, learners have had higher demands for online learning environments that increase their motivation and academic performance (Kowitlawakul et al., 2017). In parallel with this increase in learners' demands for online learning environments, learner data also accumulates (Krishnan et al., 2022; Naranjo et al., 2019). This data consists of digital footprints, defined as a set of unstructured personal data that learners leave behind in online learning environments (Donmez & Yegin, 2021; Pozdeeva et al., 2021). As learner behaviors in the learning environment are recorded, learning processes have become much easier to follow (Ulfa et al., 2019). Still, discovering learners' digital data and transforming them into usable information is a challenging process (Krishnan et al., 2022).

The interaction between the learner, teacher, and content results in the creation of big data, a rich resource for identifying the elements needed to sustain the learning process (Misiejuk et al., 2021). Such large-scale digital datasets are analyzed by data mining methods, providing a better understanding and improvement of learning-teaching processes (Kazanidis et al., 2021; Jivet et al., 2020). To obtain the desired information from big data, learning analytics needs to process this data in the desired direction. In this context, learning analytics allows for to analyze and interpret learners' digital footprints, including their learning experiences. Learning analytics, therefore, plays a key function in recording and evaluating the activities in the learning process and monitoring and improving the teaching process with opportunities for both learners and teachers (Klasnja-Milicevic et al., 2017).

Learning Analytics

Learning analytics (LA) study on collecting, measuring, analyzing, interpreting, visualizing, reporting, and evaluating the data obtained during learning and predicting learning performance (Firat, 2021; Siemens & Baker, 2012; Siemens & Long, 2011). Moreover, LA focuses on recording, analyzing, and discovering learners' digital footprints to reveal their cognitive characteristics and to give insights into their decision-making styles (Kazanidis et al., 2021). LA allows to assess learner behaviors in online learning environments, identify their needs, identify learners who are more likely to drop out, predict academic success, design efficient learning environments, and provide personalized opportunities (Cagliero et al., 2021; Kokoc & Altun, 2019; Ulfa et al., 2019). LA can also be used at various stages of education, including creating teaching materials, preparing suitable curricula, identifying learning resources, forming study plans, determining teaching strategies, and making institutional and national education policies (Klasnja-Milicevic et al., 2020).

To further improve its potential, learning analytics needs to go beyond providing one-way, source-based feedback to students (Pardo et al., 2018). A personalized learning system can provide students with individual learning support and individual adaptation to eliminate the disadvantages of a single model prepared for everyone in technology-enabled learning systems (Shemshack & Spector, 2020). The feedback to be obtained from monitoring and evaluating this process could make positive contributions to learning. This has made it possible to obtain individual results and to provide feedback and guidance in this direction.

LA is complex by nature since it involves generally large datasets and these datasets can come from numerous curricular data sources like Learning Management Systems (LMS), student information systems (SIS), Personalized Learning Environments (PLE), user data entries, interactions, logs, operation history, and other student behavior records (Pelletier et al., 2021). The process of LA abstracted in Figure 1.

Figure 1. The Process of Learning Analytics

Aside from descriptive analytics, which optimizes future learning processes by shedding light on the past, we need to employ predictive analytics, which estimates the outcomes of ongoing learning processes and allows us to take proactive actions to optimize these processes (Omedes, 2016; Omedes, 2018). Institutions that can transition from descriptive/diagnostic analytics to predictive/perspective analytics will take the lead in learning (Omedes, 2017).

Personalized Learning Environments

With an increased amount of digital data obtained from learners, e-learning environments have transformed from a joint design for many students to one or more personalized designs for each student (Altun, 2012). This is an indication of personal learning environments. The structure of personalized learning eliminates the limitations of time and place, adapting to the individual's learning history and abilities (Sampson et al., 2002; Devedzic, 2006). PLE is a new generation e-learning environment where learners learn at their own pace and preferences, focused on self-regulated learning, with personalized navigation, guidance, and evaluation through hyper-environments (BartolomÃ & Cebrian-de-la-Serna, 2017; Montebello, 2021; Raj & Renumol, 2022). In a PLE, the learner actively participates in their own learning, has a say in how they learn best, and knows how to show and prove what they learned (Bray & McClaskey, 2015).

With a learner-centered approach and effective LA use, PLE offers Artificial Intelligence (AI)-supported, adaptive, intelligent learning management systems with personalized support in line with the learner's profile (Klasnja-Milicevic et al., 2020; Maseleno, et al., 2018; Montebello, 2021; Oliveira et al., 2021). Learners interact and communicate with other learners through personalized learning environments, finding the opportunity to control their learning resources, manage the learning activities they participate in, access re-curated learning content in line with their personalized learning needs, and ensure ethical use and ownership of their learning activity data (BartolomÃ & Cebrian-de-la-Serna, 2017).

Personalized learning (PL) can be adapted to learners' strengths, interests, preferences, and needs, allowing them to regulate their own learning processes (Keci & Qosja, 2021; Kuppusamy, 2019). In other words, PL focuses on the learners' background, needs, skills, and perceptions (UNESCO, 2017). PL demonstrates how each learner's pace, preferences, and resources are tailored to their needs. Adaptation is the system's ability to adapt to the changing learner needs as they progress (Dorca et al., 2017). PL can be preferred for numerous purposes, including strengthening the learning experience, preventing dropouts, increasing interaction, and providing access to the right resources.

PLEs are online environments tailored to learners' preferences and interests, including how they use resources, and participate in activities and communities, providing a learning experience suitable for learners' needs (Zwartjes, 2018; Fournier et al., 2019). Getting to know learners based on their digital footprints is a key part of designing PLE. Here, the digital footprints of learners need to be interpreted and inferred through LA. Hence, LA can play a crucial role in designing PLE. Because, LA offers significant opportunities to encourage learners' ability to manage, monitor, and reflect on their own learning. So, e-learning environments should be adapted to increase learners' performance and satisfaction (Hwang et al., 2020). With the rapid advances in AI, cloud computing, wearable technologies, and virtual reality technologies, PLE has gained a much more comprehensive sphere of influence (Xie et al., 2019). The improvements and transformation of LA technologies have impacted the design, development, improvement, and dissemination of PLEs.

Relevant Literature

The related literature of this study is limited to the systematic literature reviews on LA and PLE. A literature search did not identify any direct systematic reviews on the use of LA for PLE. One of the most recent studies was conducted by Wong, Li and Cheung (2022) to analyze learning analytics practices to achieve personalized learning. Except for this, the relevant literature includes systematic reviews on LA in seamless learning environments (Moon et al., 2023), LA for engagement and learning performance (Johar, et al., 2023), LA in higher education (Viberg et al., 2018), LA in m/u-learning (Pishtari et al., 2020), dashboards and self-regulated learning (Matcha et al., 2019), multimodal LA (Crescenzi-Lanna, 2020), effective LA approaches to measuring learning outcomes (Blumenstein, 2020), determining the thematic structure and trends of LA research (Chen et al., 2022), LA indicators (Ahmad et al., 2022), and LA support to teachers' design (Amarasinghe et al., 2022).

Wong, Li and Cheung (2022) analyzed 144 studies. The results of the review showed that the studies were largely focused on tertiary education and online learning. The data used for learning analytics were generally related to learning activities, academic performance, educational background and learning outcomes. Improving the learning experience, providing personalized recommendations and meeting personal learning

needs were identified as the most common learning analytics and personalized learning goals. It was emphasized in this study that more research is needed on learning analytics for personalized learning.

In their systematic literature review, Moon et al. (2023) analyzed 27 emprical articles to investigate the trends and issues of learning analytics in seamless learning environments. The analyses revealed that in order to map students' learning profiles and trajectories in seamless learning environments, existing research has largely focused on extending multimodal data collection and analysis. In addition, researchers are able to systematically drive adaptive learning through the emerging use of automated data collection and computational metrics.

Johar et al. (2023) analyzed 42 articles with the help of PRISMA, highlighting the types of learner engagement that the use of learning analytics can indicate, in the hope of improving learner performance in online learning. The results showed that some studies measured multifaceted engagement to improve student learning. However, the number of studies was limited. The inclusion of social, cognitive, collaborative, behavioral and emotional engagement in online learning was therefore recommended for future research.

Viberg et al. (2018) analyzed 136 reports and 116 articles on "LA in higher education" from 2012 to 2018. Accordingly, the relevant literature dealt with using LA in higher education, the methods adopted for LA, whether LA improves learning outcomes, whether LA supports learning and teaching, and whether it is used ethically. The authors have emphasized that LA has a high potential in improving learning outcomes, supporting teaching and learning, and ethical use of personal data, with great expectations for it, though the use of LA in higher education, is not yet at the desired level. Hence, they drew attention to the scarcity of research to support these expectations. However, with the widespread use of LA in higher education, future research can provide a deeper understanding of students' learning experiences and the potential impact of LA on learning outcomes.

Pishtari et al. (2020) performed a systematic review on learning design in m/u-learning and LA. The authors provided an overview of the current research trend. Besides, based on similar learning contexts and research gaps, they suggested that m/u learning should be explored beyond higher education, the link between physical and virtual learning environments should be strengthened, and learning design and learning analytics should be integrated more systematically.

Matcha et al. (2019) conducted a systematic review of empirical findings regarding the effects of learning analytics dashboards (LADs) on learning and teaching. The authors highlighted LAD designs based on experiments and research should be preferred, instead of a priori designs. Therefore, they recommended the "user-centered learning analytics systems (MULAS)," which consists of four dimensions that are cyclically and iteratively interconnected, including theory, design, feedback, and evaluation.

Crescenzi-Lanna (2020) performed a systematic review of multimodal learning analytics studies to identify useful tools and strategies for assessing learning progress and behaviors among children below the age of 6 years. The aim was to guide multimodal learning analytics research with children 6-year-old children to assess their participation in tasks, emotions, attention, understanding, and achievements. The author found that the current knowledge in the literature showed how to use performance analytics, facial and speech recognition systems, eye tracking, kinetic analytics, and wristbands in children. Crescenzi-Lanna highlighted that ethical issues were the focus of multimodal data obtained from audio, visual, biometric, and quantitative behavior measurements.

Blumenstein (2020) conducted a systematic review on the effect sizes of 38 key studies following effective LA approaches to measure learning outcomes. Accordingly, learning designs that support socio-collaborative and independent learning skills were found to have positive effects on student achievements. Recent trends in personalizing student feedback have revealed the need to integrate student-specific factors into improving student experiences and academic outcomes. As a key finding, the author drew attention to the LA Learning Gain Design (LALGD), a new three-level model that synchronizes capturing significant data with pedagogical goals and learning outcomes. The author reported the model to be suitable for face-to-face and online environments, or a mix of both, contributing to data-based learning in higher education.

Chen et al. (2022) analyzed 3900 articles on LA to identify the thematic nature and trends of LA research. The main questions were "what research topics are the LA community interested in?" and "how have these

research topics evolved?" The authors made use of structural topic modeling and bibliometrics. Major journals, countries/regions, institutions, and scientific collaborations were examined and visualized. According to their findings, the country that contributed the most to the LA literature was the USA, followed by the UK and Australia. Besides, the USA, the UK, Australia, Spain, and Germany collaborated the most, while the most LA collaborations were made between Australia and the UK. The most collaborations in LA research by institutions were observed in Open University (UK), University of Technology Sydney, Carnegie Mellon University, and the Open University of the Netherlands. Also, the University of Edinburgh and the University of South Australia collaborated on most articles. By publications, the most prominent institution was the Open University. Moreover, most citations with regards to LA were observed for Educational Technology and Society, Internet and Higher Education, and Computers and Education. The most prominent topics were combining various innovative technologies like visual dashboards, neural networks, multimodal technologies, and open learner models to support learning experiences, personalized suggestions/feedback, self-regulated learning in flipped classrooms, game-based exercises, and interaction practices in social learning.

Ahmad et al. (2022) analyzed 161 articles on LA, to identify the indicators of learning design (LD). Two important results stood out in the study. First result is that the researchers proposed a reference framework in which they present the possible connections between these two concepts to achieve a good fit between LA and LD; second, the researchers demonstrated how LA indicators and metrics have been studied in the past. According to the study, learning activities are the key factor for both LA and LD, therefore, the basic indicator and link in both is learning activity. The first conclusion that the researchers reached when they examined the articles of the past decade was that there was no clear definition of LA indicators and measures. It was also pointed out that there some conflicting definitions of learning activities and the consideration of some activities as learning activities such as mouse clicks were not pedagogically correct. As a result, the researchers proposed a framework that determines the LA indicators and their measurement.

Amarsinghe et al. (2022), in their study, aimed to fill the literature gap on whether teachers can use the same LA indicators in both LD and learning management of learning activities. For this purpose, they shared the results of 17 articles in their study. As a result of the literature review, it has been seen that the LA indicators used in the learning design and the LA indicators used in the orchestrating of learning activities differ from each other. Accordingly, the researchers presented the indicators that can be used for LD and the LA indicators that can be used for the management of learning activities as two different categories in a single framework.

Table 1. Systematic reviews regarding LA and PLE

Authors, year	Which years were included (from - to)	Main points of the systematic reviews
Viberg et al. (2018)	2012-2018	LA in higher education
Pishtari et al. (2020)	2008-2019	LA in m/u-learning
Matcha et al. (2019)	2010-2017	Dashboards and self-regulated learning
Crescenzi-Lanna, (2020)	2014-2019	Multimodal LA
Blumenstein, (2020)	2011-2016	Effective LA approaches to measuring learning outcomes
Chen, Zou and Xie, (2022)	2010-2019	determining the thematic structure and trends of LA research
Ahmad et al. (2022)	2011-2020	LA indicators
Amarasinghe et al. (2022)	2012-2020	LA support to teachers' design
Moon et al. (2023)	No time limit	LA in seamless learning environments
Johar et al. (2023)	2011-2021	LA for engagement and learning performance
Wong, Li and Cheung (2022)	2012-2019	LA practices to achieve personalized learning environments

As can be inferred from the literature review and Table 1., there are systematic literature reviews on the different aspects of LA. However, no systematic literature review could be found regarding to determine the trends and tendencies of LA to the formation of PLE, which is one of its ultimate goals. Therefore, this systematic literature review will contribute to filling this gap in the related literature.

Research Purpose

The purpose of this research was to determine trends and tendencies of the articles on Learning Analytics for Personalized Learning Environments from the Scopus database. To identify trends in the field, we addressed the following research questions:

1. What are the leading countries and institutions conducting research on LA for PLE?
2. What/who are the leading journals and authors of research on LA for PLE?
3. What is the LA for PLE research trend?

METHODOLOGY

This study designed as an systematic literature review. The identified keywords for the systematic literature review were "Learning Analytics" and "Personalized Learning Environments." Data collected from Scopus database. Elsevier Scopus is recognized as the world most comprehensive and qualified database due to its extensive coverage across various disciplines, rigorous selection process, and global reach. It offers comprehensive citation analysis, enabling researchers to assess the impact of scholarly work.

In our attempts for a pilot search with the keywords of "Learning Analytics" AND "Personalized Learning Environments.", we could not reach sufficient articles. To extend the number of results, we added the keyword "Personal Learning Environments" as an alternative phrase to "Personalized Learning Environments." The final search phrase is given below.

(TITLE-ABS-KEY ("Learning Analytics") AND TITLE-ABS-KEY ("Personal Learning Environment") OR TITLE-ABS-KEY (ple) OR TITLE-ABS-KEY ("Personal Learning Environment") OR TITLE-ABS-KEY (personal*)) AND (LIMIT-TO (DOCTYPE , "ar"))

As can be understood from the phrase, the search covers all years and is limited to journal articles. This search listed 329 documents including all article types. The 329 articles were further checked with the following criteria for inclusion:

1. articles on personalized learning through learning analytics (screening process conducted by 7 researcher),
2. the articles were written in English and
3. the full text of the article could be accessed.

Only the articles which fully met all the criteria were selected. Thus, 284 articles that met all criteria were included in the analysis. Figure 2 shows the distribution of documents by year.

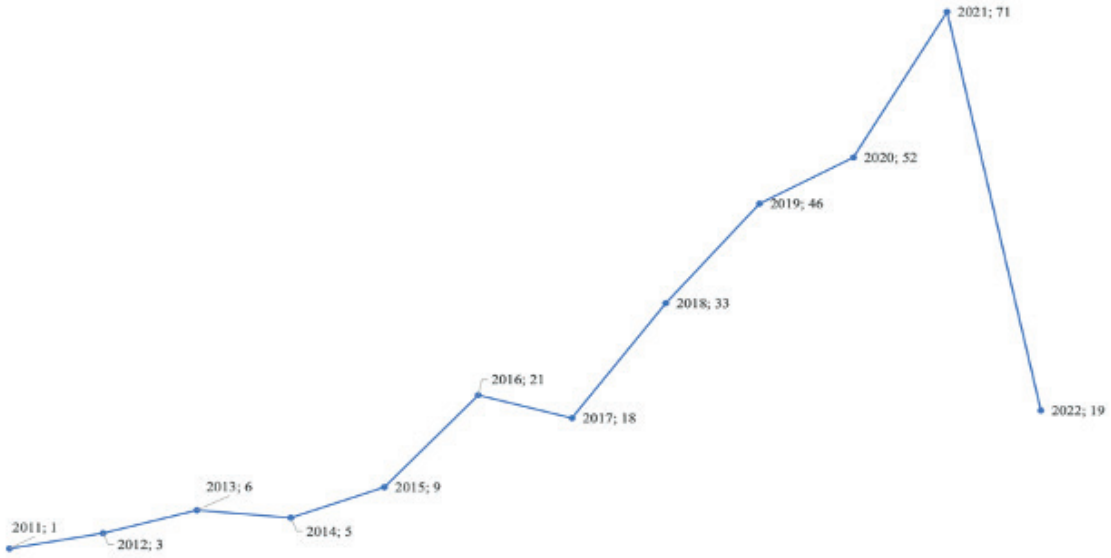

Figure 2. Publications by Year

The number of publications on LA for PLE seems to have increased from 2011 to 2022. Since the screening was carried out before the end of 2022, the number of articles published in this year is lower in the graph compared to the previous few years.

Data Analysis

Bibliographic data of 284 articles were exported from Scopus as a CSV file. The selected bibliometric information included the author(s), document title, source title, number of citations, affiliations, and keywords. We performed a data cleaning for each file, leaving only the names of institutions and countries in affiliations. The rest of the address information was removed from the file. We used the VOSviewer software to determine the most frequently used keywords in AI and LA studies and to visualize the results. Also, the network map of co-authorships, co-occurrences, co-citations, coupling analysis was created with the full counting method. VOSviewer 1.6.18 was used to visualize the similarities of articles on LA for PLE. VOSviewer is a software tool for constructing and visualizing bibliometric networks. The data collection and data analysis processes were reviewed by 7 different researchers. The researchers enhanced validity and reliability by implementing data cleaning techniques according to specific criteria, utilizing specialized software tools, involving multiple researchers for review and validation. These measures contribute to the trustworthiness of the study.

RESULTS

The findings obtained from the bibliographic data analysis are presented under the relevant headings for each research question.

Leading Countries and Institutions

To determine the countries of the publications, we downloaded their country data from Scopus and visualized them in a bubble graph in the Tableau data visualization software. Figure 3 shows the distribution of publications by country.

As seen in Figure 3, the USA was in the lead with 67 publications on LA for PLE, followed by Australia, Spain, and the UK with more than 30 publications each. 284 articles were produced by researchers from 67 different countries. Figure 4 below gives the co-authorship network by country. While creating the map, we

selected the type of analysis as co-authorship and the unit of analysis as a country. The minimum number of publications from one country was 2. Of the 67 countries, 48 met the threshold.

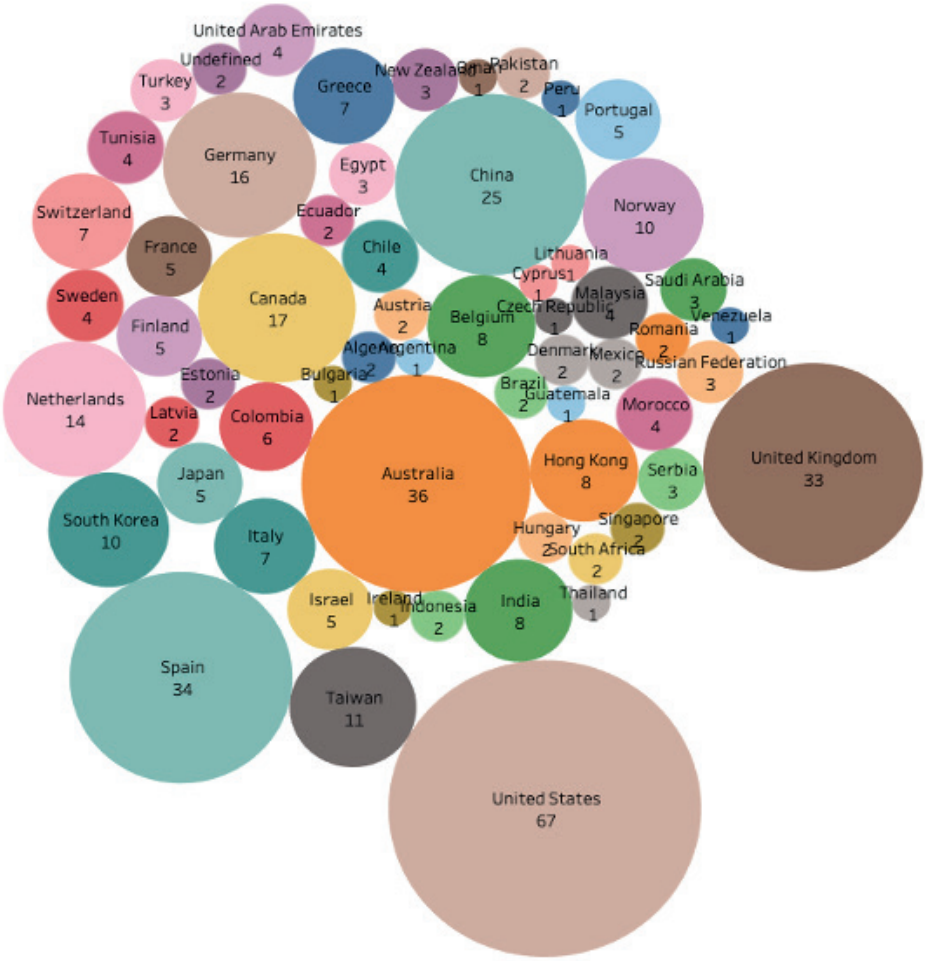

Figure 3. Bubble Graph of The Distribution of Publications by Country

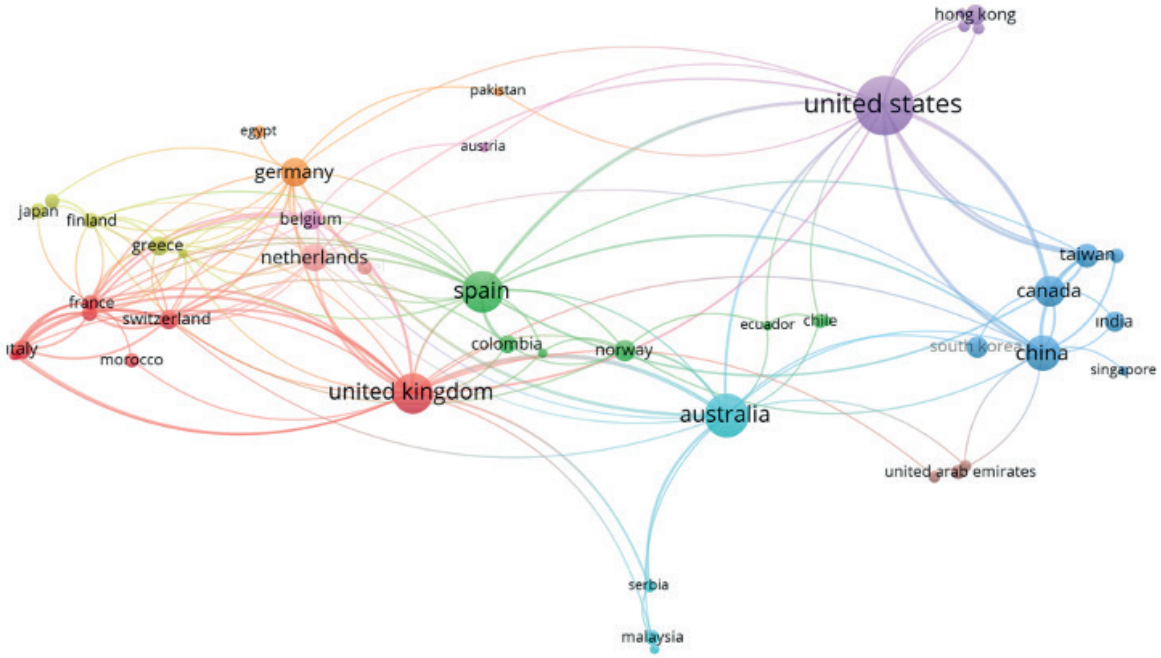

Figure 4. Co-Authorship Network Map of Leading Countries

Each node in the network is proportional in size to the number of publications. Thicker links between nodes represent a higher number of co-authorships. As seen in the network, there were 10 clusters. The leading countries in these clusters were the USA (NDocuments=67, NCitations=1712), Australia (ND=37, NC=932), Spain (ND=34, NC=423), the UK (ND=32, NC=524), China (ND=25, NC=219), Canada (ND=18, NC=599), Germany (ND=16, NC=413), the Netherlands (ND=15, NC=650), and Taiwan (ND=11, NC=241). Spain, the UK, and Australia acted as connectors in the network.

We created another VOSViewer network map from bibliographic data to identify the leading institutions. Figure 5 shows the network map of institutions. When creating the network map, we selected the type of analysis as co-authorship and the unit of analysis as a country. The minimum number of publications from one country was 5. Of the 440 institutions, 9 met the threshold.

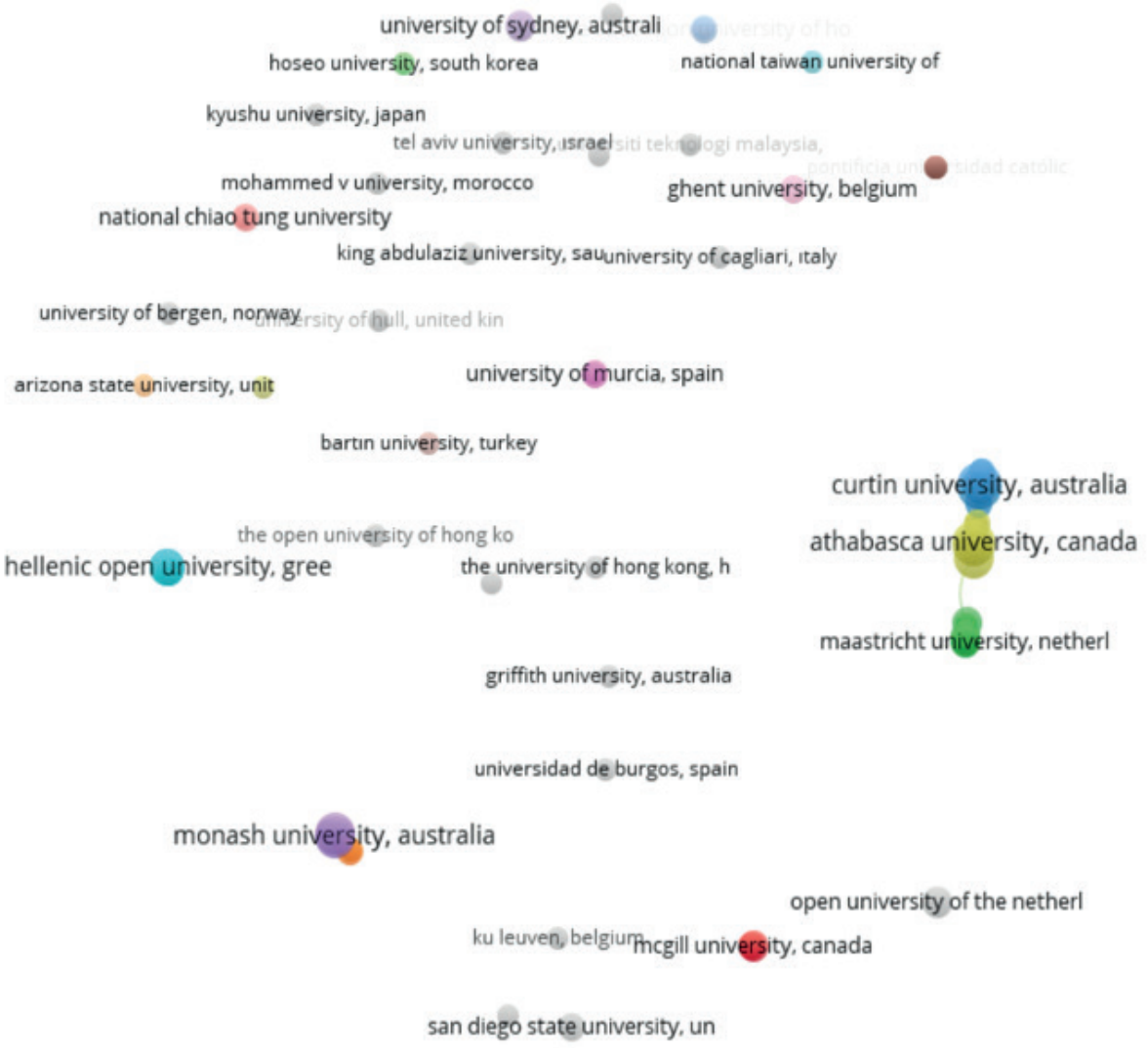

Figure 5. Co-Authorship Network Map of Leading Institutions

We observed that only 19 out of 86 institutions had co-authorship links. According to the number of publications, the leading institutions in terms of research on LA for PLE were Curtin University (ND=9, NC=298), Athabasca University (ND=8, NC=536), University of South Australia (ND=7, NC=168), Monash University (ND=7, NC=90), Beijing Normal University (ND=7, NC=34), University of Mannheim (ND=6, NC=243), and University of North Texas (ND=6, NC=60).

Leading Journals and Authors

The 284 articles were published in 133 different journals. When ranked according to the number of publications, 82 journals made only 1 publication, while the remaining 202 articles were distributed among the remaining 51 journals. Accordingly, 17 journals had 2 publications each, 12 journals had 3 publications each, 5 journals had 4 publications each, and 6 journals had 5 publications each, reaching a total of 120 articles by 40 journals. Table 2 below shows the ranking of 11 journals with 6 or more publications.

Table 2. Top 11 Journals by Number of Publications and Citations

Journals	Citations	Publications
	n	n
Interactive Learning Environments	145	14
Sustainability (Switzerland)	30	8
Technology, Knowledge and Learning	204	7
International Journal of Artificial Intelligence in Education	36	7
IEEE Transactions on Learning Technologies	190	7
Educational Technology Research and Development	121	7
Educational Technology and Society	558	7
Computers in Human Behavior	487	7
Journal of Universal Computer Science	72	6
Frontiers in Education	10	6
Australasian Journal of Educational Technology	26	6

According to Table 2, Interactive Learning Environments ranked first with 14 publications, followed by Sustainability (Switzerland) with 8 publications. The journals named Technology, Knowledge and Learning, International Journal of Artificial Intelligence in Education, IEEE Transactions on Learning Technologies, Educational Technology Research and Development, Educational Technology and Society, and Computers in Human Behavior had 7 publications each. The three journals with 6 publications each were the Journal of Universal Computer Science, Frontiers in Education, and Australasian Journal of Educational Technology. Considering the number of citations, Educational Technology and Society ranked first with 558 citations, followed by Computers in Human Behavior with 487 citations.

In the present research, we retrieved 284 articles published by 902 authors. Figure 6 shows the co-authorship network map of these articles. The minimum number of publications and citations by a single author was 2. Of the 902 authors, 110 met the threshold.

Figure 6. Co-Authorship Network Map of 110 Authors

As the graph shows, there were many co-authorship clusters among the authors. Table 3 below shows the 7 most prominent authors according to the number of publications and citations.

Table 3. Top 7 Authors by Number of Publications and Citations

Author	Institution and Country	Publications n	Citations n
Hendrik Drachsler	Leibniz Institute for Research and Information in Education, Netherlands	2	451
Abelardo Pardo	University Carlos III of Madrid, Spain	9	374
Wanli Xing	University of Florida, USA	7	286
Dirk Ifenthaler	University of Mannheim, Germany; Curtin University, Australia	5	237

Clara Schumacher	University of Mannheim, Germany	3	207
Dragan Gasevic	Monash University, Australia	5	183
Shane Dawson	University of South Australia, Australia	4	143

Abelardo Pardo had the most publications with 9 articles, while Hendrik Drachsler had the most citations at 451. Of the 110 authors who met the threshold of a minimum of 2 publications and 2 citations, 24 authors had a linked network. Regarding the prominent authors in the co-authorship cluster, there was a link between Abelardo Pardo and Burgos D. across co-authorship clusters. Also, there were links between Burgos and Tlili; Pardo, Dawson, and Gasevic; Ifenthaler, and Schumacher. Xing and Drachsler had a co-authorship cluster independent of the other prominent authors. Figure 7 shows the co-authorship network map of the 24 linked authors.

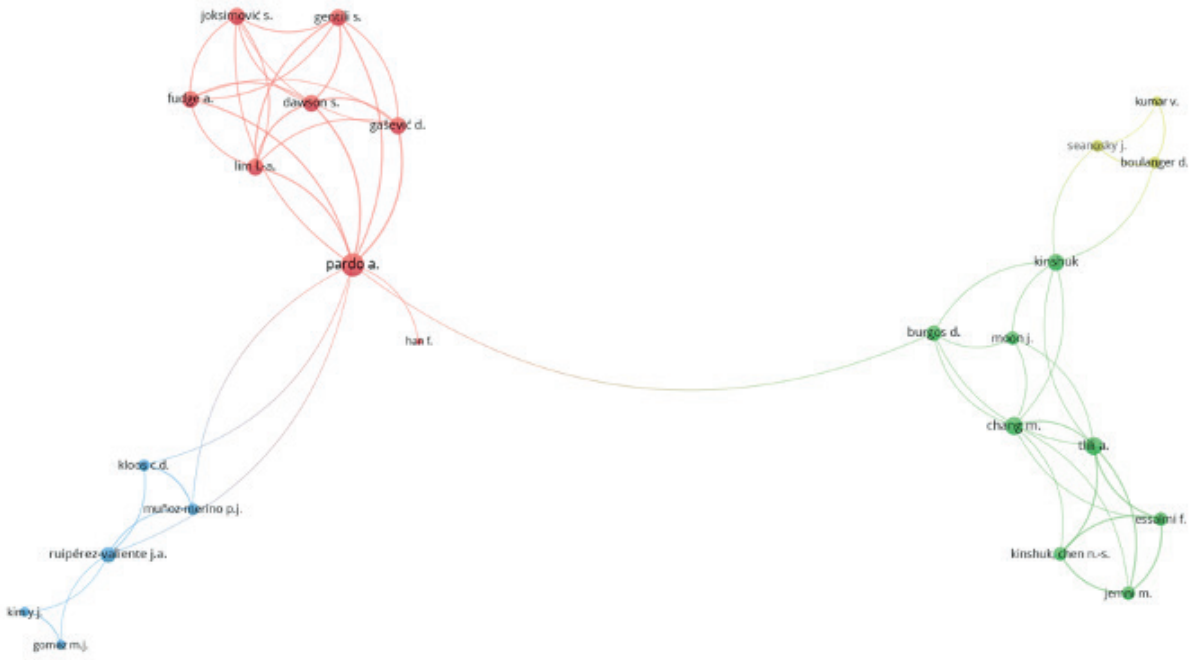

Figure 7. Co-Authorship Network Map of 24 Linked Authors

As can be seen in Figure 7, there were 4 clusters in the network. Pardo and Burgos had a central location and formed links between clusters. Han was linked to Pardo's cluster but was disconnected from all other clusters. Han's article with Pardo was titled "Combining University student self-regulated learning indicators and engagement with online learning events to Predict Academic Performance," with the following keywords: computer-assisted instruction; education; learning management systems; personalized e-learning.

LA for PLE Research Trend

The co-occurrence analysis of keywords was conducted with the full counting method. Figure 7 shows the network map of keywords. The minimum number of occurrences for a keyword was 4. Of the 856 keywords, 40 met the threshold. Also, the keywords "Learning Analytics," "Personalized Learning," "Personal Learning Environment," "Personalization," Personal Learning Environments," and "Personalised Learning" were removed from the analysis as they were the main subject of the research. Thus, Figure 8 shows the 36 keywords.

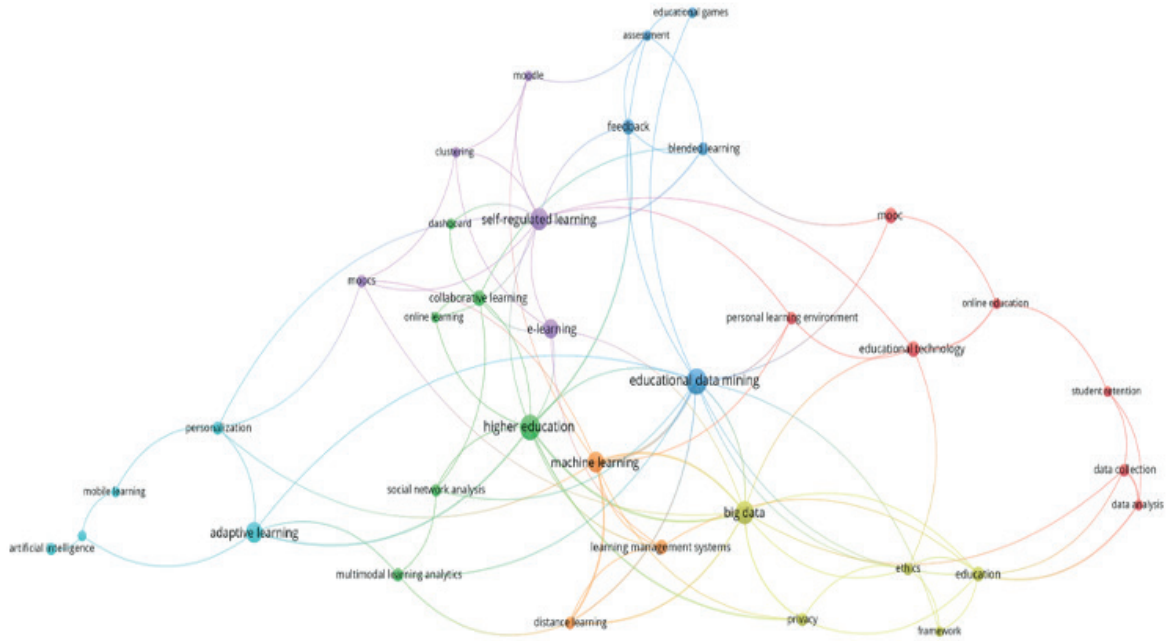

Figure 8. Co-Occurrence Map of Keywords

Figure 8 indicates 7 clusters in different colors. These clusters include the keywords that stood out according to the number of occurrences and the number of total link strength (NTLS). "Educational data mining" (Number of Occurrence=23, NTotal Link Strength=43) and "higher education" (NO=23, NTLS=43) were the most prominent keywords in terms of their centrality, overall weight, density, and degree of overlap with the other keywords. Other keywords with more than 10 occurrences were "big data" (NO=18, NTLS=34), "self-regulated learning" (NO=16, NTLS=26), "machine learning" (NO=14, NTLS=29), "adaptive learning" (NO=14, NTLS=25), and "e-learning" (NO=12, NTLS=13). Figure 9 gives an overlay visualization map of keywords by years to reveal the changes in LA for PLE research trends over time.

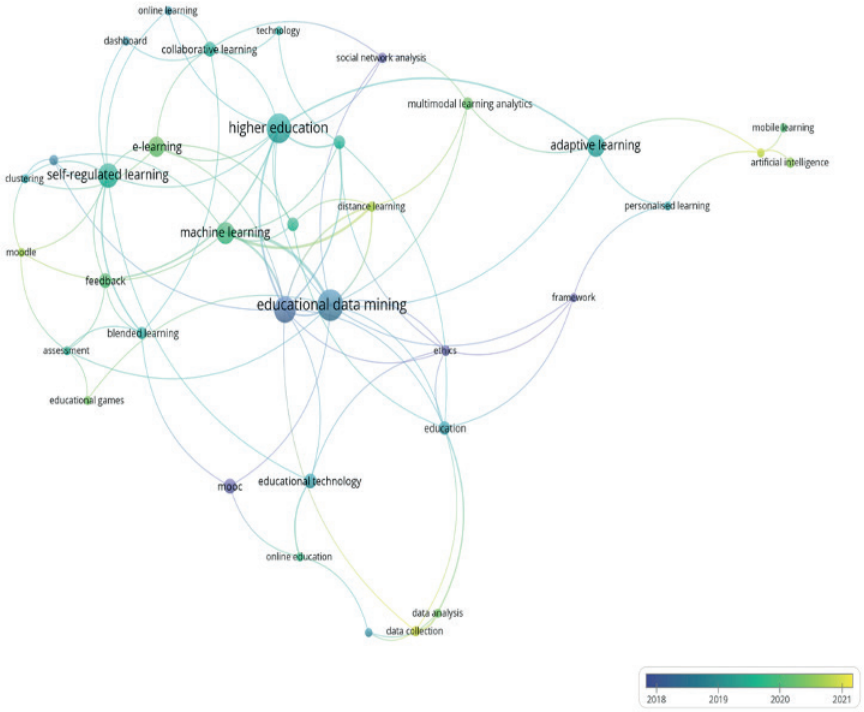

Figure 9. Overlay Visualization Map of Keywords

Given the changes throughout the years, "educational data mining," "big data," and "social network analysis" were prominent keywords before 2018-2022, while "adaptive learning," "artificial intelligence," and "smart learning environments" were more prominent in recent articles. Note that the former keywords were mostly associated with data and analysis phases, while the more recent ones are associated with the action phase. This indicates that LA research has recently focused on practical studies. To see a holistic network map of articles, we conducted a bibliographic coupling analysis. Figure 10 shows the overlay visualization map of the bibliographic coupling analysis.

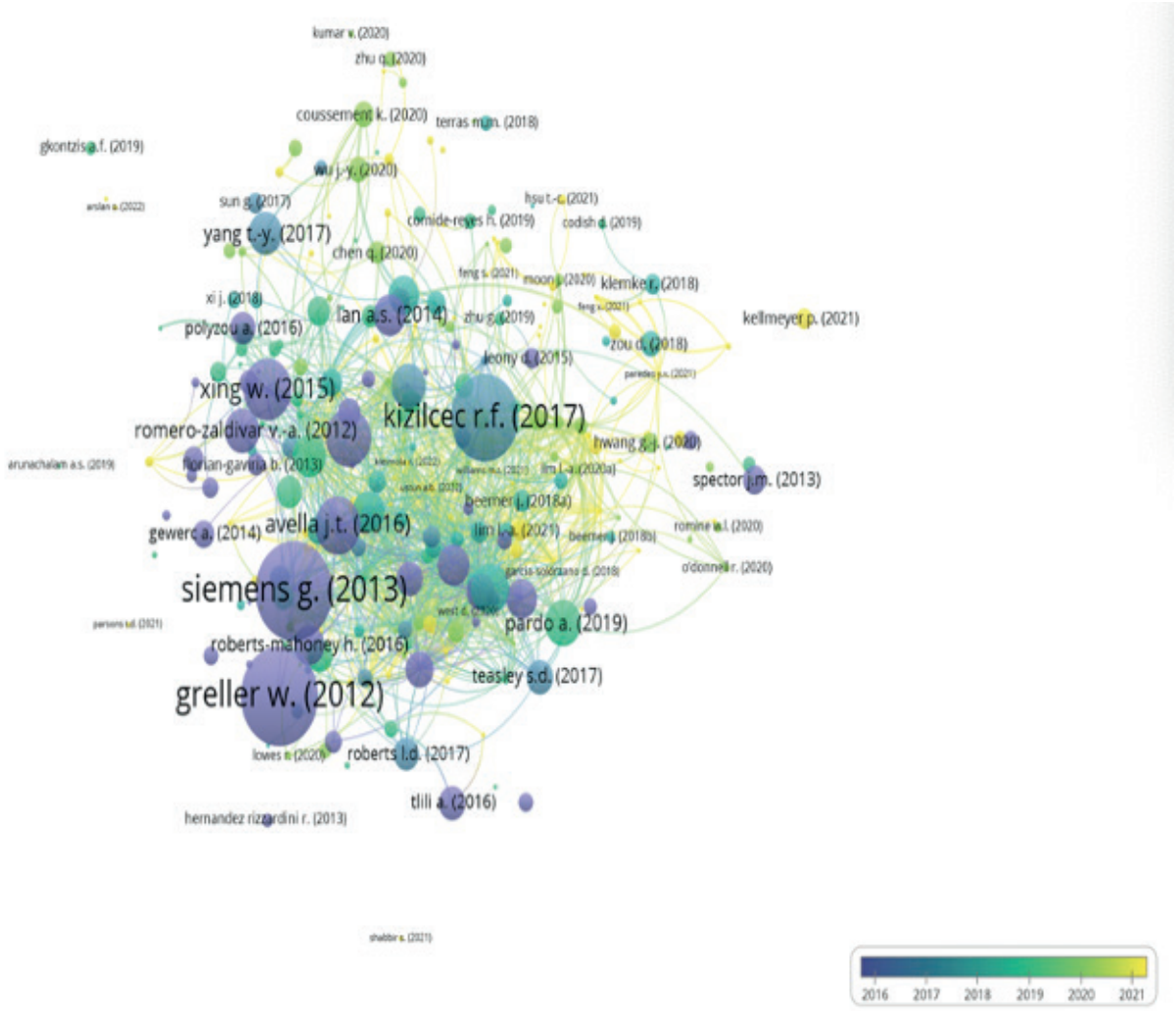

Figure 10. Bibliographic Coupling Analysis of Articles

Bibliographic coupling, like co-citation, is a similarity measure that uses citation analysis to establish a similar relationship between publications. As expected, older articles were cited more, as evident in Graph 9. Table 4 shows the most cited articles (100+).

Table 4. Most Cited Articles (100+)

Authors	Title	Year	Source title	Cited by
Greller W., Drachsler H.	Translating learning into numbers: A generic framework for learning analytics	2012	Educational Technology and Society	451
Siemens G.	Learning Analytics: The Emergence of a Discipline	2013	American Behavioral Scientist	450

Kizilcec R.F., Perez-Sanagustin M., Maldonado J.J.	Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses	2017	Computers and Education	345
Xing W., Guo R., Petakovic E., Goggins S.	Participation-based student final performance prediction model through interpretable Genetic Programming: Integrating learning analytics, educational data mining and theory	2015	Computers in Human Behavior	178
Avella J.T., Kebritchi M., Nunn S.G., Kanai T.	Learning analytics methods, benefits, and challenges in higher education: A systematic literature review	2016	Journal of Asynchronous Learning Network	158
Kay J., Reimann P., Diebold E., Kummerfeld B.	MOOCs: So many learners, so much potential.	2013	IEEE Intelligent Systems	157
Schumacher C., Ifenthaler D.	Features students really expect from learning analytics	2018	Computers in Human Behavior	118
Pardo A., Jovanovic J., Dawson S., Gasevic D., Mirriahi N.	Using learning analytics to scale the provision of personalized feedback	2019	British Journal of Educational Technology	102

The co-citation analysis of the cited references was conducted with the full counting method. The minimum number of citations for a reference was limited to 5. Of the 13617 cited references, 22 met the threshold. Figure 11 shows the co-citation network map of 21 linked articles.

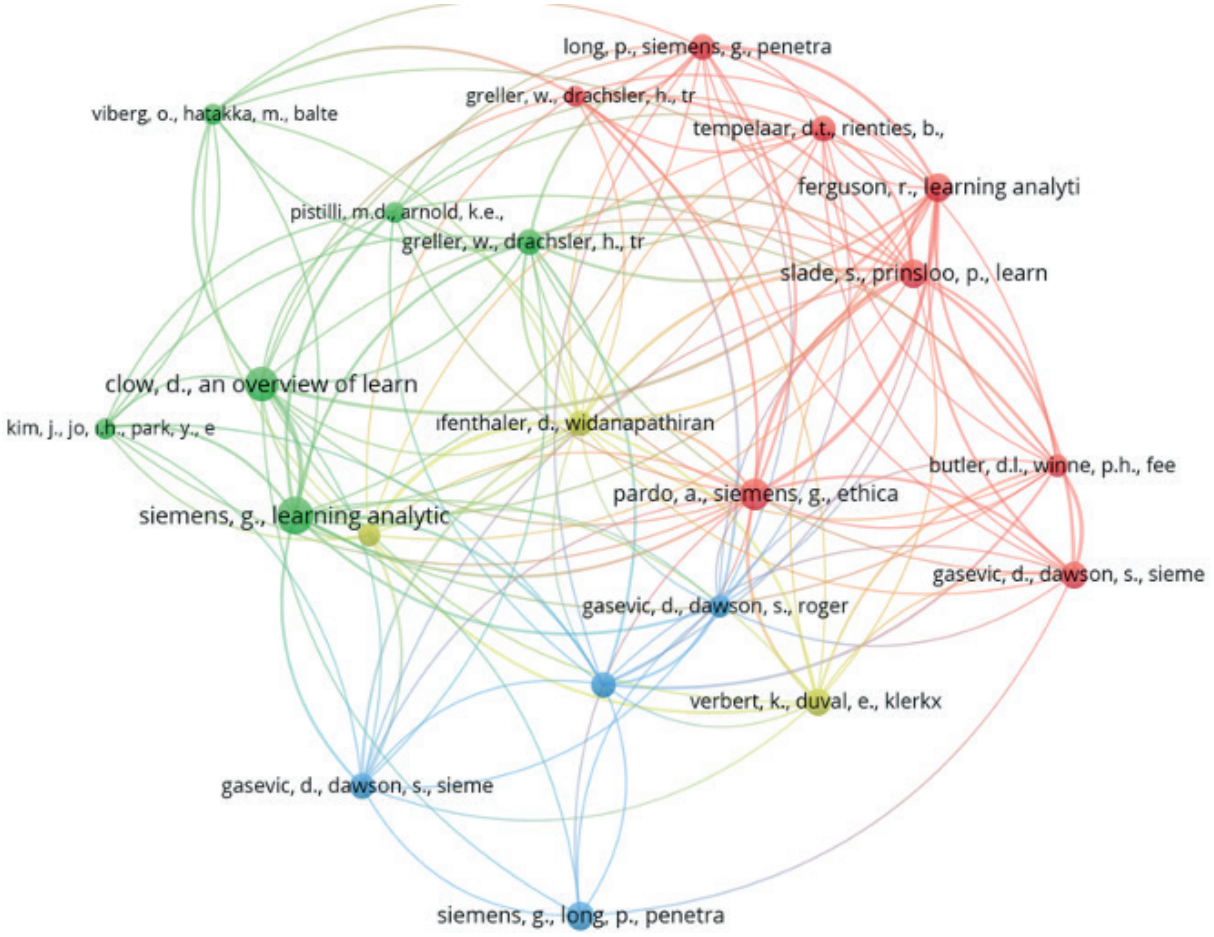

Figure 11. Co-Citation Analysis Map of Articles

The co-citation analysis map included 4 clusters. Table 5 gives the distribution of articles to clusters, weights of links, total link strength, and citations of articles.

Table 5. The Distribution of Articles to Clusters Based on Co-Citation

Article	Cluster	Weight <Links>	Weight <Total link strength>	Weight <Citations>
Butler, D.L., & Winne, P.H.(1995). Feedback and self-regulated learning: A theoretical synthesis.	Theory of LA	13	20	6
Ferguson, R.(2012). Learning analytics: drivers, developments and challenges.	Theory of LA	15	29	9
Gasevic, D., Dawson, S., & Siemens, G. (2015). Let's not forget: Learning analytics are about learning.	Theory of LA	12	19	8
Greller, W. & Drachsler, H. (2012). Translating learning into numbers: A generic framework for learning analytics.	Theory of LA	11	16	5
Siemens, G. & Long, P. (2011). Penetrating the fog: Analytics in learning and education.	Theory of LA	15	20	7
Pardo, A. & Siemens, G. (2014). Ethical and privacy principles for learning analytics.	Theory of LA	18	31	11
Slade, S. & Prinsloo, P. (2013). Learning analytics: Ethical issues and dilemmas.	Theory of LA	15	29	9
Tempelaar, D. T., Rienties, B., & Giesbers, B. (2015). In search for the most informative data for feedback generation: Learning analytics in a data-rich context.	Theory of LA	12	13	7
Clow, D.(2013). An overview of learning analytics.	LA Overviews	15	23	13
Greller, W. & Drachsler, H. (2012). Translating learning into numbers: A generic framework for learning analytics.	LA Overviews	15	21	7
Kim, J., Jo, I.H. & Park, Y. (2016). Effects of learning analytics dashboard: analyzing the relations among dashboard utilization, satisfaction, and learning achievement.	LA Overviews	9	10	5
Pistilli, M.D. & Arnold, K.E. (2010). Purdue Signals: Mining real-time academic data to enhance student success.	LA Overviews	11	13	5
Siemens, G. (2013). Learning analytics: The emergence of a discipline.	LA Overviews	17	32	16
Viberg, O., Hatakka, M., Balter, O., & Mavroudi, A. (2018). The current landscape of learning analytics in higher education.	LA Overviews	9	11	5

Gasevic, D., Dawson, S., Rogers, T., & Gasevic, D. (2016). Learning analytics should not promote one size fits all: The effects of instructional conditions in predicting academic success.	Why LA	14	17	6
Gasevic, D., Dawson, S., & Siemens, G. (2015). Let's not forget: Learning analytics are about learning.	Why LA	12	15	7
Hattie, J., & Timperley, H. (2007). The power of feedback.	Why LA	14	18	7
Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education.	Why LA	7	7	9
Schumacher, C., & Ifenthaler, D. (2018). Features students really expect from learning analytics.	LA in Action	12	18	6
Verbert, K., Duval, E., Klerkx, J., Govaerts, S., & Santos, J. L. (2013). Learning analytics dashboard applications.	LA in Action	12	17	8
Ifenthaler, D., & Widanapathirana, C. (2014). Development and validation of a learning analytics framework: Two case studies using support vector machines.	LA in Action	18	29	7

Here, we analyzed the subjects of the articles in the aforementioned 4 clusters. Cluster 1, colored in red, was named "Theory of LA." Accordingly, Butler and Winne (1995) theorized the importance of using self-regulated learning and feedback together for effective learning; Ferguson (2012) examined the factors driving the development of LA; Gasevic et al. (2015) gave recommendations from research on LA for the realization of learning; Greller and Drachsler (2012) examined key dimensions and critical problem areas of LA, and potential dangers to the beneficial use of learning data; Siemens and Long (2011) investigated the benefits of using LA in higher education; Pardo and Siemens (2014) examined the ethical principles of using LA; Slade and Prinsloo (2013) gave recommendations for the ethical use of LA; Tempelaar, Rienties, and Giesbers (2015) highlighted the significance of informative feedback in the predictive modeling of student performance using LA.

Cluster 2, colored in green, was named "LA Overviews." Accordingly, Viberg et al. (2018) reviewed previous research on using LA in higher education from 2012 to 2018; Clow (2013) investigated the benefits, uses, and challenges of LA; Greller and Drachsler (2012) examined key dimensions and critical problem areas of LA, and potential dangers to the beneficial use of learning data; Kim et al. (2016) reviewed previous research on the effects of using LADs as personalized feedback tools on student satisfaction and learning achievements; Pistilli and Arnold (2010) investigated efforts for supporting learner success by mining real-time academic data; Siemens (2013) studied the research areas that contributed to the development of LA, models of LA, data ownership when using LA, and ethical privacy concerns.

Cluster 3, colored in blue, was named "Why LA." There were 4 prominent studies in this cluster. Accordingly, Gasevic et al. (2016) investigated the prediction of student achievements using LA; Gasevic et al. (2015) gave recommendations from relevant research on LA for the realization of learning; Hattie and Timperley (2007) investigated the effect of feedback on learning and achievement; Siemens and Long (2011) studied the benefits of using LA in higher education.

Cluster 4, colored in yellow, was named "LA in Action." Here, Schumacher and Ifenthaler (2018) investigated the expectations of university students regarding LA features; Verbert et al. (2013) researched examples of LAD applications; Ifenthaler and Widanapathirana (2014) examined the benefits and challenges of using LA.

DISCUSSION AND CONCLUSION

This study is limited with the bibliometric network analyses based on co-authorships, co-occurrences, co-citations and coupling analyzis of 284 articles published between 2011-2022. Here, we present a discussion of our findings and our conclusions under relevant sub-headings for each research question. The study in the relevant literature where the findings related to the first two research questions can be discussed is limited to Chen et al. (2022). This is because country-, institution-, author- and journal-based trend identification studies are limited to this study. Similarly, country-, institution-, author- and journal-based trend findings are presented from a more descriptive perspective without further evaluation, interpretation and practical implications.

What Are the Leading Countries and Institutions Conducting Research on LA for PLE?

The 284 articles about LA for PLE were written by researchers from 67 different countries. The USA, Australia, Spain, and the UK were the leading countries for several publications. This is similar to the findings of Chen et al. (2022). Chen et al. (2022) found that the USA had the most contributions to the LA literature with 24% of all relevant publications, followed by the UK and Australia. The co-authorship network map of leading countries formed 10 clusters, including the USA, Australia, Spain, the UK, the USA, China, Canada, Germany, the Netherlands, and Taiwan. Also, Spain, the UK, and Australia played a connector role in the network. This is again in parallel with the findings of Chen et al. (2022). Chen et al. (2022) reported that the USA, the UK, Australia, Spain, and Germany collaborated the most, while the most collaborations on LA occurred between Australia and the UK. The institutions with the most collaborations in LA were the Open University (UK), University of Technology Sydney, Carnegie Mellon University, and The Open University of the Netherlands. Besides, the University of Edinburgh and the University of South Australia collaborated on most articles (Chen et al., 2022). In terms of articles on LA for PLE by the number of publications, the leading institutions in descending order were Curtin University, Athabasca University, University of South Australia, Monash University, Beijing Normal University, University of Mannheim, and the University of North Texas. The Open University, on the other hand, was the leading institution in terms of LA research (Chen, et al., 2022).

What/who are the Leading Journals and Authors of Research on LA for PLE?

Interactive Learning Environments was the leading journal on LA for PLE with 14 publications, followed by Sustainability (Switzerland) with 8 publications. Regarding the number of citations, the leading journals were Educational Technology and Society and Computers in Human Behavior. Chen et al. (2022) observed the most cited journals on LA as Educational Technology and Society, Internet and Higher Education, and Computers and Education. Our findings correlate with theirs with regards to the journal with the most citations, i.e., Educational Technology and Society. The 284 articles were published by 902 authors. 110 of these authors had at least 2 publications. Abelardo Pardo was the leading author with 9 articles, while Hendrik Drachsler led the ranking of most citations at 451. Also, Pardo and Burgos stood out in terms of centrality and linking between clusters. However, Hendrik Drachsler was not linked to any of the clusters despite having a high number of citations.

LA for PLE Research Trend

To reveal the LA for PLE research trend, we conducted a keywords co-occurrence analysis, an overlay visualization of keywords, and a bibliographic coupling analysis of articles. According to the keywords co-occurrence analysis, the leading keywords were “educational data mining” and “higher education” in terms of their centrality, overall weight, density, and degree of overlap with the other keywords. We also analyzed the changes in keywords by year. Accordingly, the most prominent keywords in 2018 (data mining and big data) were mostly aimed at the data and analysis phases of LA. In 2021 and 2022, the most prominent keywords shifted to “adaptive learning,” “artificial intelligence,” and “smart learning environments,” relating more to the action phase of LA. This shows that LA has rapidly completed its development and passed into

the application and adaptation phases. This finding highlights the "need for integrating student-specific factors" as also previously identified by Blumenstein (2020) and Pishtari et al. (2020). According to Pishtari et al. (2020), most publications on learning design (LD) and LA focused on formal education in higher education and on physical and virtual environments. Although, "the effects of monitoring time devoted to learning" was one of the main topics covered regarding LA and LD research. One of the most prominent subjects in LA research was the subject of usefulness. Also, the most cited studies revolved around the subject of "the usage of LA for evidence-based decision making" (Pishtari et al., 2020). Hence, our findings of the research trend indicate a shift from theory to practice, supporting the systematic review of Chen et al. (2022). Our co-citation analysis of the articles revealed 4 clusters, named "Theory of LA," "LA Overviews," "Why LA," and "LA in Action." Accordingly, the articles on LA for PLE have mostly been theoretical, until now; in recent years, however, authors have been ready to put it into practice. Moreover, the book titled "Learning Analytics: Fundaments, Applications, and Trends" by Leitner et al. (2017) states that LA research has mostly focused on "the usage of massive online open courses (MOOCs), enhancement of learning performance, student behavior, and benchmarking of learning environments." Finally, Matcha et al. (2019) investigated the literature about LADs and found that "self-regulated learning" has been the focus of LA and LAD research.

Suggestions

Based on our findings and understandings from this study, we have made the following suggestions:

- Future research on LA for PLE can comfortably deal with practical applications rather than theoretical and conceptual studies. The contributions of using AI and NLP in LA to form PLEs is a particularly interesting subject and is deserving of experimental investigation.
- Since online learning environments are rather suitable for LA, these environments should make much greater use of LA, beyond just LADs, to help achieve PLEs. We believe that this necessitates the production and dissemination of advanced LA components, software, and plug-ins that can be integrated into LMS and other e-learning environments. The usage of LA should be able to go beyond dashboards.

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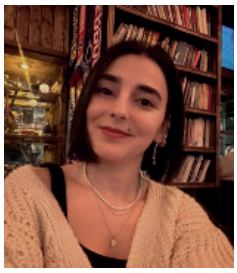

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INTEGRATING SEGMENTING AND GAMIFICATION PRINCIPLES IN THE DESIGN OF INTERACTIVE GAMIFIED PROGRAMMING ASSESSMENTS FOR LOW ACHIEVERS

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ABSTRACT

This paper discusses the design of interactive gamified assessments for an introductory programming course based on the multimedia segmenting principle and gamification. The objective is to develop more engaging online programming assessments for low-achieving students. The general design follows Nielsen's design guidelines and incorporates Zaharias' usability evaluation framework with the motivation to learn. The methodology employed the Successive Approximation Model Version 2 (SAM2), comprising two key phases: preparation and iterative design. In the initial phase, a comparative analysis was performed to determine the design principles. The iterative design phase encompassed the application's design via storyboards, the development of the high-fidelity prototype, and users' reviews. A qualitative approach was adopted, involving a user-centred design (UCD) session through focus group discussions with 12 first-year students from the Diploma of Computer Science program, all of whom were low achievers in programming. The participants need to review and rate the prototype based on the scales of the usability recommendations, which are visual design, content design, navigation, interaction, gamification design, and multimedia design. The results from the UCD session revealed that all participants agreed with the usability recommendations integrated into the interactive gamified programming assessments, with the highest mean score of 5.00.

Keywords: Interactive, assessment, programming, segmenting principle, gamification.

INTRODUCTION

Several studies have utilised online learning to facilitate the teaching and learning of introductory programming. For instance, Poonsawad, Srisomphan, and Sanrach (2022) have constructed an interactive digital story learning based on problem-based learning and gamification that focuses on improving students' problem-solving skills. Besides that, Alsubhi, Ashaari, and Wook (2021) have proposed that game elements can be integrated into each level of e-learning activities, such as levels in course learning material, badges, and timers in-course assessment and course assignment, and avatars for discussion segment. Their target was to improve students' engagement in terms of behavioural, emotional, and cognitive factors. Meanwhile, Carbonaro (2018) has utilised a web-based peer code review and assessment to provide feedback to peers and promote students' engagement and participation in the coding experience. The web-based assisted system supports students' programming competence, engagement, and time management capabilities.

Meanwhile, integrating multimedia into online learning for programming has also been widely implemented. For example, Yamani (2021) has developed an adventure game-based multimedia learning that combines gamification elements with multimedia technology. Moreover, Mutiawani, Elfa, Jumadin, Amiren, Fauzie Afidh, and Subianto (2018) have developed a web-based learning with multimedia named Markas C that supplemented the teaching and learning of C programming at Syiah Kuala University in Indonesia. The idea behind integrating multimedia learning into an e-learning portal was to provide an interactive learning environment for students.

However, integrating multimedia learning principles and gamification into the design of interactive online gamified assessments is still in its early stages. As Mayer (2020) suggested, multimedia learning principles aim to reduce unnecessary cognitive load, regulate intrinsic load, and optimise germane load. On the other hand, gamification principles, when properly implemented, can enhance students' motivation and engagement in the learning process (Alabbasi, 2017; Khaleel, Ashaari, Wook & Ismail., 2017). In programming education, students who struggle with this subject are often called low achievers (Turkmen & Caner, 2020; Kadar, Wahab, Othman, Shamsuddin & Mahlan, 2021). These students frequently encounter challenges in understanding fundamental programming concepts, resulting in decreased motivation and interest (Turkmen & Caner, 2020; Kadar et al., 2021). Therefore, educators must find technological solutions that cater to the specific learning needs of these low achievers. Thus, this paper presents the process of designing and developing interactive gamified programming assessments by integrating multimedia learning and gamification principles to support self-regulated learning among low achievers and boost their interest and motivation in this course. Other general design principles for the proposed interactive gamified assessment environment, such as Nielsen's design guidelines for college students aged 18 to 24 years old on the web (Loranger, McCloskey & Nielsen, 2014) and Zaharias's usability evaluation framework with motivation to learn (Zaharias, 2009) were also discussed in this paper.

BACKGROUND OF STUDY

Issues with Low-Achieving Students in Introductory Programming

During the initial semester of Computer Science studies, the introductory programming course is compulsory for students (Mehmood, Abid, Farooq & Nawaz, 2020). Furthermore, Mehmood et al. (2020) emphasise the importance of students possessing robust algorithmic and logical thinking skills to excel in computer programming. These cognitive abilities systematically determine students' problem-solving ability using problem-solving strategies and methodologies (Silva, Mendes & Gomes, 2020). Nevertheless, a common challenge many novice-level students may face when studying this subject is their frequent struggle to create programs that address specific problems (Silva et al., 2020). In simpler terms, these students often need help to grasp the fundamental concepts of problem-solving, which demands higher-order computational thinking abilities such as analytical thinking and reasoning (Mehmood et al., 2020). Singh and Narang's (2014) cognitive enhancement hypothesis also claims that underdeveloped logical and reasoning skills can lead to difficulties in other abstract areas of learning, such as mathematical equations, problem-solving, and analytical skills. Due to these difficulties, low-achieving students often feel less motivated as they find the subject complex and challenging. This will eventually cause high failure and dropout rates in many higher learning institutions (Othman, Osman, Abdullah & Ahmad, 2022; Kadar et al., 2021; Mehmood, 2020).

Gamification in Learning Programming

According to Chao (2015), gamification refers to using game design elements in contexts unrelated to games. In education, gamification is a strategy incorporating game design features to motivate and engage students, significantly improving their curricular, cognitive, and social skills (Alabbasi, 2017; Nadja, 2022). It involves the implementation of tactics that prompt learners to respond, inspire action, and facilitate learning and problem-solving (Alabbasi, 2017; Nadja, 2022). This approach empowers learners, making tasks more appealing and fostering collaboration, effort, and other positive attributes associated with games (ChePa & Yahaya, 2020; Poonsawad et al., 2022).

Moreover, for students with lower academic performance, integrating gamification into educational technology can help enhance their motivation to learn programming. These students, often called slow learners, encounter difficulties grasping the fundamental concepts of programming (Kadar, Mahlan, Shamsuddin, Othman & Wahab, 2022; Multazam, Syahrial & Rusmono, 2023). Their limited ability to logically solve problems leads to difficulty completing assignments and decreases motivation (Kadar et al., 2022; Multazam et al., 2023). Therefore, gamification elements can potentially motivate this group of students and promote their engagement in the learning process. Some gamification principles Chao (2015) suggested to enhance students' understanding and motivation include achievement, progression, feedback, and social influence, among others. Furthermore, gamification elements such as badges, points, levels, and progress bars can be implemented in an online learning environment, as Yamani (2021) proposed.

Multimedia in Learning Programming

Given humans' limited capacity for real-time information processing, instructional design should strive to create multimedia that reduces unnecessary load, regulates intrinsic load, and optimises germane load. Mayer (2020) proposes twelve principles of multimedia learning to do this, including coherence, signalling, redundancy, spatial contiguity, and temporal contiguity. These principles can be employed to reduce extraneous load. Meanwhile, the segmenting, pre-training, and modality concepts may all be employed to regulate intrinsic load (Mayer, 2020). The multimedia, personalisation, voice, and picture principles are the last four multimedia learning principles utilised to optimise germane load (Mayer, 2020).

These days, numerous academicians in programming education have included Mayer's multimedia learning principles in their design of multimedia learning applications. For instance, Cheah and Leong (2019) investigated the effect of the redundancy principle on C++ programming learning using screencasting, a video recording of the activity on a computer screen activity, usually accompanied by audio narrations. According to their research, students fared better when screen casting and narration were used than when screen casting, narration, and on-screen text were used. Meanwhile, Kumar Kaushal, Kumar, Panda, and Sood (2021) examined the usefulness of signalling, segmenting, and modality principles in teaching data structures using computer animations. Their study demonstrated that using segmentation and modality concepts in animation has increased students' performance in learning programming, particularly data structures.

Based on the background of the study discussed above, this research strives to answer these research questions:

RQ1: What are the suitable gamification and multimedia learning principles to be employed in the design of the programming assessment for low-achieving students?

RQ2: How can the selected gamification and multimedia learning principles be integrated into the design of the programming assessment for low-achieving students?

METHODOLOGY

We used the Successive Approximation Model Version 2 (SAM2) by Allen (2014) as our methodology to answer the formulated research questions. SAM2 is the extended version of the ADDIE model that incorporates an iterative design process (Allen, 2014). It was selected based on the fact that learning design methods can be adapted to fit iterative approaches, which SAM2 has to offer. SAM2 consists of three main phases: the preparation phase, the iterative design phase, and the iterative development phase. However, only

the first two main phases were discussed in this paper, as the design of the gamified programming assessment will undergo another cycle of reviews before commencing the prototype development. The two main phases and their activities are explained as follows:

Preparation Phase

During the preparation phase, a comparative analysis was conducted to identify and extract the appropriate gamification and multimedia learning principles to be integrated into the interactive gamified programming assessments. To achieve this, various existing studies that focused on gamified programming e-learning models and interactive video models that incorporate multimedia learning principles were selected. The comparative analysis aimed to extract and integrate gamification and multimedia learning principles into designing interactive gamified programming assessments for low achievers in introductory programming. The selection of these models was based on predefined criteria: a clear and detailed discussion of gamification and multimedia usage in e-learning models and the application of multimedia learning principles in interactive learning applications. Other than that, usability recommendations that serve as the basis for the general design of the interactive gamified programming assessment environment were also explored in this phase, such as Nielsen's design guidelines for college students between the ages 18 and 24 on the web (Loranger et al., 2014) and usability evaluation framework with motivation to learn by Zaharias (2009).

Iterative Design Phase

In the second phase, three main activities were conducted: application design, prototype development and user reviews. The explanation for each activity is as follows:

Design the Application

To demonstrate the integration of gamification and multimedia learning principles in designing the interactive gamified programming assessments, a series of storyboards were created using storyboardthat.com based on the selected principles and recommendations identified in the first phase. One crucial factor to consider in designing the storyboards for the interactive gamified programming assessments was to align it with the learning content. As the application aimed to provide interactive and effective online assessments for low achievers in programming, the assessments focused on problem analysis and algorithm development to enhance learners' analytical and problem-solving skills before moving on to coding skills. The interactive gamified programming assessments were segmented into three phases based on problem-solving and algorithm development: problem analysis, pseudocode development, and flowchart development, where each phase consists of a question-and-answer section.

Prototype Development

Developing a high-fidelity prototype was the next step to showcase the navigation and interactivity of the interactive gamified programming assessments. The gamified assessments' interfaces were designed using the Canva app based on the storyboards developed earlier. They also featured multimedia elements such as text, video, audio, animation, and graphics. The selected gamification principles were also applied in the interactive gamified assessment segments. Subsequently, the application was integrated into LifterLMS, a learning management system developed using WordPress. The interactivity of the gamified assessments was designed and supported through the H5P WordPress plugin.

Users' Reviews

For data gathering, a focus group discussion was employed, utilising a qualitative approach through a user-centred design (UCD) session, which involved 12 low-achieving students from the first year of the Diploma in Computer Science program. All participants were low-achieving students who enrolled in introductory programming classes and were selected based on their logical-thinking test scores. The instrument used

to measure their logical thinking levels was the Group Assessment Logical Thinking (GALT) Test, which produced a Cronbach's alpha reliability coefficient of 0.722 (Othman et al., 2022). GALT consists of six logical subscales testing such as conservational reasoning, proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial reasoning, which are compiled into 12 test questions (Roadrangka, 1991). Students who scored six marks or less were considered low logical thinking students, thus representing the low achievers for this study. The summary of the participants' demographic info and GALT results is depicted in Table 1.

Table 1. Demographic info of the participants for focus group discussion

	Demographic Info		
Age	Male	Female	Total
18 - 19	6	6	12
GALT Results			
0 – 1	1	1	2
2 – 4	2	3	5
5 - 6	3	2	5

During the UCD session, the participants were presented with the interactive gamified programming assessment prototype, and later, they were encouraged to explore and interact with it individually. A questionnaire using a Likert scale of 1 to 5 was also constructed to indicate Strongly Disagree to Strongly Agree, consisting of various design scales, including visual design, content design, navigation, interaction, gamification design, and multimedia design. This instrument was later validated through content validity by three content experts in multimedia, interaction design, and information technology before the UCD session. Each expert must rate 1 for relevant and 2 for not relevant for each item in the instrument. The formula used to calculate the content validity index (CVI) is CVI = n/N, where n is the number of items that are confirmed relevant, and N is the total number of items in the instrument (Rwothumio, Okaka, Kambaza & Kyomukama, 2021). Each expert has recorded a CVI of more than 0.90, which indicates the instrument's validity. The questionnaire was then provided to the participants so they could review and rate the design of the prototype. Finally, the data from the questionnaire were analysed using descriptive analysis via IBM SPSS 26 Statistics.

RESULTS AND DISCUSSIONS

The results from each phase of the research methodology explained previously will be discussed in this section.

Preparation Phase: Selection and Integration of the Gamification and Segmenting Principle

Comparative Analysis

To identify the appropriate gamification and multimedia learning principles for integration into the gamified online programming assessments, we have chosen ten existing studies of e-learning with gamification and five existing studies that integrate multimedia learning principles into their interactive video learning. As mentioned earlier, these studies were selected based on these predefined criteria: i) a clear and detailed discussion of gamification and multimedia usage in e-learning models and ii) the application of multimedia learning principles in interactive learning applications. Therefore, all these selected studies have explored and modelled the integration of gamification and multimedia learning principles for novices in programming. Table 2 depicts the comparative analysis of the selected e-learning study with gamification and multimedia.

Table 2. Comparative analysis of the existing studies of e-learning with gamification

No	Studies	Gamification Principle	Gamification Elements	Application of Gamification in the Content
1	Nadja (2022)	Rules and challenges, achievement, empowerment	Levels, badges, rewards	Assessment
2	Poonsawad et al. (2022)	Achievement, rules and challenges, competition, progression, narrative	Points, levels, badges, storyline, achievements, competition, progression	Assessment
3	Alsubhi et al. (2021)	Achievement, competition, progression, feedback, levels, ownership	Levels, badges, timer, Avatar, progress bar, leaderboard	Learning & Assessment
4	Yamani (2021)	Achievement, competition, progression, feedback, social engagement	Points, badges, leaderboard	Assessment
5	Kamunya et al. (2020)	Achievement, competition, rules and challenges, altruism	Points, badges, levels, leaderboard	Learning & Assessment
6	Alshammari (2019)	Feedback, achievements, competition	Levels, rewards, badges, points, leaderboard	Learning & Assessment
7	Shamsuddin et al. (2018)	Feedback, achievement, progression	Points, badges, leaderboard	Assessment
8	Khaleel et al. (2017)	Achievement, competition, self-expression, altruism	Points, badges, levels, progress bar, leaderboard, Avatars	Learning & Assessment
9	Piteira et al. (2017)	Feedback, achievement, social engagement, rules and challenges	Points, badges, progress bar, leaderboard	Learning & Assessment
10	Malas & Hamtini, (2016)	Narrative, progression, achievement	Points, badges, levels	Learning & Assessment

The comparative analysis presented in Table 2 highlights the prevalent use of gamification principles in previous studies, with achievements, progression, and rules and challenges being the most employed principles in both learning and assessment segments. Meanwhile, progress bars, badges, levels, and points are the frequently used gamification elements. These findings suggest that these game elements are well-suited for implementation in this study's interactive gamified assessment segments. Additionally, it is recommended that these gamification principles be employed in this study to enhance the engagement, motivation, and achievement of low achievers in introductory programming.

Another comparative analysis was conducted to identify suitable multimedia learning principles for integration into the gamified assessments. This analysis selected and examined five studies that utilised interactive videos for learning. The selected studies and multimedia learning principles are presented in Table 3.

Table 3. Comparative analysis of the existing studies of interactive video with multimedia learning principles

No	Studies	Multimedia Learning Principles	Descriptions
1	Draus (2020)	Segmenting principle	The study suggests providing segmented videos in chunks of 5 to 10 minutes, which positively impacts students' engagement in learning programming. The research also indicates that low-performing students perform better after watching the instructional videos more frequently.
2	Kumar Kaushal et al. (2020)	Signalling, Segmenting, and modality principles	The study investigates the usefulness of signalling segmentation and modality principles in teaching data structures using computer animations. The results have shown that animations with segmentation and modality principles have increased students' performance in learning data structures.
3	Li, Liu, Wang, Zhong & Yu (2019)	Segmenting principle	The study investigates students' debugging process via eye-tracking assessment, where the segmenting principle is applied in tracking eye movement based on specified code errors within the related code blocks.
4	Cheah & Leong (2019)	Redundancy principle	The study investigates the effectiveness of the redundancy principle in two different modes: video, narration and text, and video and narration only. The latter mode proves to be more effective in learning C++ programming.
5	Chen & Yen (2019)	Segmenting and modality principles	The study investigates the learner control, segmentation, and modality effects in animated demonstrations. The studies have shown the positive effects of segmentation and learner control on novices with smaller chunks of information.

The results presented in Table 3 show that the segmenting principle has been frequently utilised in designing interactive videos for leawrning programming, as evidenced by most of the selected studies. As a result, this principle has been chosen to be incorporated into the design of this study's interactive gamified programming assessments. The following justifications have been made for selecting the segmenting principle:

i. When used with the learner control principle, the segmenting principle allows learners to match their learning pace with their individual cognitive needs, enhancing their engagement (Cheah & Leong, 2019; Li et al., 2020).
ii. Studies have shown that the segmenting principle, along with learner-pacing, effectively reduces cognitive load and improves transfer performance (Chen & Yen, 2019; Draus, 2020).
iii. According to research, students learn better from multimedia lessons presented in user-paced segments rather than as a continuous unit, which is achieved through the segmenting principle (Kumar Kaushal et al., 2020; Li et al., 2020).

Therefore, Table 4 shows the gamification design and multimedia design's usability recommendations, as extracted based on the selected gamification principles and the segmenting principle.

Table 4. Usability recommendations are based on the selected gamification principles and the segmenting principle.

Gamification and Multimedia	Usability Recommendations
Gamification Design	1. Utilize rules and challenges to enhance learners' cognitive skills (application of rules and challenges principle).
	2. Display learners' progress in completing challenges with a progress bar (application of progression principle).
	3. Award badges for each achievement, such as a Progress Badge for completing each level of challenge (application of achievement principle).
	4. Assign points for completing a challenge (application of achievement principle).
Multimedia Design	1. Learning is more effective when multimedia content is segmented into smaller, easily digestible segments (application of multimedia segmenting principle).
	2. User-controlled presentation of multimedia content leads to better absorption of information (application of multimedia segmenting principle).

As mentioned previously, apart from the gamification and multimedia design usability recommendations in Table 4, to make the interactive gamified programming assessments more effective and motivating to the target users, the general design of the prototype is also being guided by Nielsen's design guidelines for college students on the web age 18 to 24 years old (Loranger et al., 2014) and usability evaluation framework with motivation to learn (Zaharias, 2009). Nielsen's design guidelines were chosen because of their effectiveness in guiding the design of interactivity and navigation between the application and the target users. Meanwhile, usability recommendations from Zaharias (2009) were deemed suitable for triggering motivation among low achievers. Therefore, Table 5 shows the selected usability recommendations that become the prototype's general design, consisting of visual design, content design, navigation, and interaction.

Table 5. General design's usability recommendations

General Design	Usability Recommendations based on Nielsen's Design Guidelines and Zaharias Usability Evaluation Framework with Motivation to Learn
Visual Design	1. Attract with clean, simplistic design
	2. Feature visual design that matches the learning content
	3. Use colours sparingly
Content Design	1. Choose words and concepts that are related to the learners (Computer Science students)
	2. Learning contents are divided into small, clear groupings.
	3. Minimize redundancy (using text, images, video, animation, and narration is appropriate).
	4. Has a question-and-answer format related to the learning contents.
Navigation	1. Use familiar navigation schemes.
	2. Learners can choose (easily) what parts of the course to access, the order and pace of studying.
Interaction	1. Use media appropriately to assist in highlighting and learning critical concepts.
	2. The course provides meaningful interactions (for example, embedded quizzes) when there are long sections of text or video.
	3. The course uses game elements or simulations, role-playing activities, and case studies to gain attention and maintain learners' motivation.
	4. The course engages learners in tasks closely aligned with the learning goals and objectives.

Upon completion of the preparation phase, the first research question was answered, and we successfully determined the suitable gamification and multimedia learning principles to be integrated into the design of the programming assessment for low-achieving students.

Iterative Design Phase: Design of the Storyboard

After selecting the gamification and segmenting principles and the other general design guidelines, the design process of the interactive gamified programming assessments' storyboard followed. The content of the interactive gamified assessments was segmented, focusing on problem-analysis and design activities, as stated in the methodology section. Several crucial factors were considered in integrating the multimedia segmenting principle into the interactive gamified programming assessments' design. These include the assessment's segmentation, gamification elements to be integrated, and user pace control and interactivity features.

Segmentation of the Interactive Gamified Assessment

To enhance the learning experience of introductory programming, problem analysis and design are divided into different phases, including problem analysis, problem design using pseudocode, and problem design with flowcharts. Thus, each phase will have its corresponding assessment segment in the interactive gamified assessments. Furthermore, a question-and-answer section with an interactive quiz will be incorporated into each phase to make the assessment segments more engaging. These segments will also feature multimedia elements like text, graphics, audio (narration), and animation.

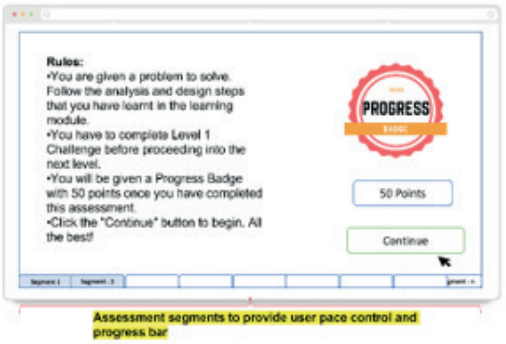
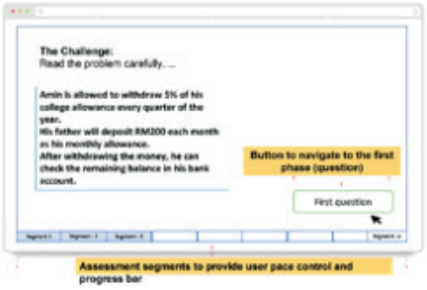
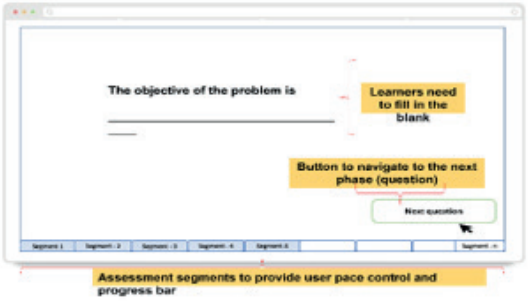
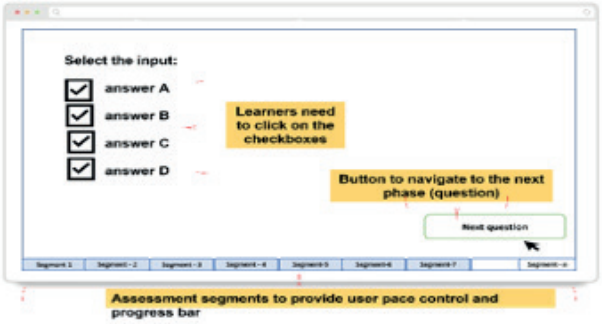
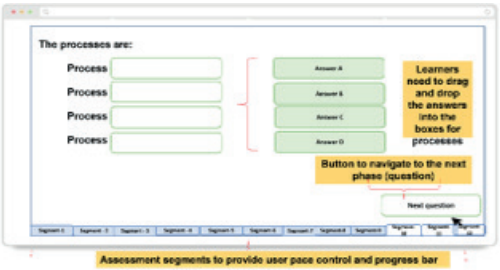
Integrating Gamification Elements into the Assessment

To incorporate gamification elements into the design of the interactive assessment, challenge questions were categorised into three difficulty levels: Easy, Moderate, and Hard. Each challenge level had rules for learners to follow, including earning points and badges upon completion. Advancement to the next level of challenges depended on completing the previous level. No timer was included to alleviate pressure, as the primary goal was to motivate low-performing students to finish the assessment. A progress bar was added to display the percentage of the learner's progress, serving as a tool for motivation and engagement.

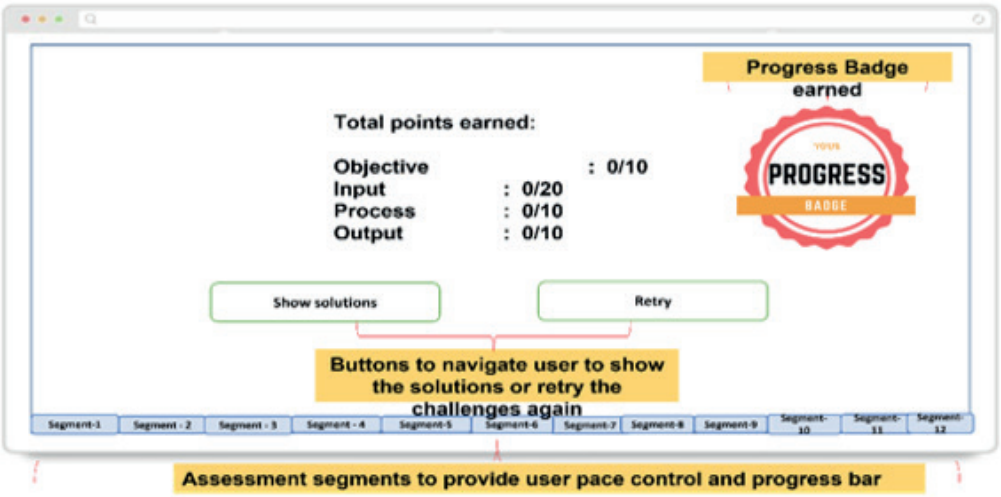
Integrating User Pace Control and Interactivity Features

The segmenting multimedia learning theory endorses the notion of learners learning at their own pace, particularly for those who struggle academically. Thus, no timer was added to regulate the duration for learners to complete each assessment level by the user pace control theory and the segmenting principle. The interactive assessments featured graphics and animations to aid learners in navigating through the phases of each challenge and completing the embedded interactive quizzes. Table 4 presents a sample of each interactive gamified assessment storyboard with gamification elements and segmentation.

Table 4. Sample of the storyboard for the interactive gamified programming assessment with gamification and segmenting principles

Sample of storyboard for the interactive assessment segments with gamification and segmenting principles – Challenge Level 2 (Moderate)	
 **Segment:** Introduction **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Progress bar	 **Segment:** Rules **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Badge, points, progress bar
 **Segment:** Challenge Question **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Badge, points, progress bar	 **Segment:** Interactive question-and-answer (fill in the blank) **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Badge, points, progress bar
 **Segment:** Interactive question-and-answer (checkboxes) **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Badge, points, progress bar	 **Segment:** Interactive question-and-answer (drag and drop) **Multimedia elements:** Text, graphics, animation, audio and video **Gamification elements:** Badge, points, progress bar

Sample of storyboard for the interactive assessment segments with gamification and segmenting principles – Challenge Level 2 (Moderate)



Segment: Total score
Multimedia elements: Text, animation
Gamification elements: Badge, points, progress bar

Iterative Design Phase: Development of the High-fidelity Prototype

The high-fidelity prototype was developed since the participants must experience how interactivity and navigation are executed in a natural learning environment. Figure 1 shows the interactive gamified programming assessment interfaces constructed based on the previously developed storyboard, where all the usability recommendations were employed. In the interactive gamified programming assessment segments, the gamification principles applied are the rules and challenges represented by the questions asked, the progression principle represented by the progress bar, and the achievement principle presented via the points scored and badges earned. Meanwhile, the multimedia learning principle applied is the segmenting principle

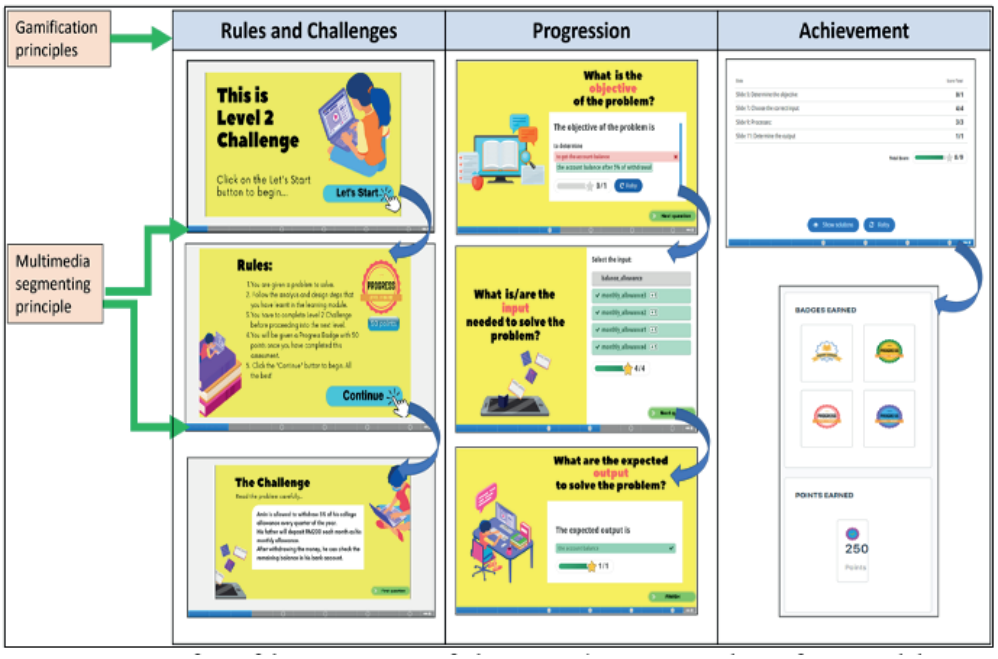


Figure 1. Interfaces of the interactive gamified assessment's prototype with gamification and the segmenting principle

Iterative Design Phase: Users' Reviews

As mentioned earlier, the participants in the UCD session were asked to review and rate the design of the interactive gamified assessment based on the scales of visual design, content design, navigation, interaction, gamification design and multimedia design. The results of the descriptive analysis derived from the UCD session are depicted in Table 5.

Table 5. Results of UCD session

Visual Design	**Mean**	**Std. Dev.**
Attract with a clean, simplistic design	4.50	.522
Feature visual design that matches the learning content	4.83	.389
Use colours sparingly	4.75	.452
Content Design		
Choose words and concepts that are related to the learners (Computer Science students)	4.75	.452
Learning contents are divided into small, clear groupings.	4.67	.492
Minimize redundancy (using text, images, video, animation, and narration is appropriate).	4.83	.389
Has a question-and-answer format related to the learning contents.	4.83	.389
Navigation		
Use familiar navigation schemes.	4.67	.492
Learners can choose (easily) what parts of the course to access and the order and pace of studying.	4.75	.452
Interaction		
Use media appropriately to assist in highlighting and learning critical concepts.	4.83	.389
The course provides meaningful interactions (for example, embedded quizzes) when there are long sections of text or video	4.92	.289
The course uses game elements or simulations, role-playing activities, and case studies to gain attention and motivate learners.	4.92	.289
The course engages learners in tasks closely aligned with the learning goals and objectives.	4.92	.289
Gamification Design		
Utilize rules and challenges to enhance learners' cognitive skills (application of rules and challenges principle).	5.00	.000
Display learners' progress in completing challenges with a progress bar (application of the progression principle).	4.92	.289
Award badges for each achievement, such as a Progress Badge for completing each level of challenge (application of achievement principle).	5.00	.000
Assign points for completing a challenge (application of achievement principle).	4.75	.452
Multimedia Design		
Learning is more effective when multimedia content is segmented into smaller, easily digestible segments (application of multimedia segmenting principle).	4.75	.452
User-controlled presentation of multimedia content leads to better absorption of information (application of multimedia segmenting principle).	4.83	.389

Based on the results of the UCD session in Table 5, the participants agreed on the usability recommendations in the prototype design, with mean scores between 4.50 and 5.00. The gamification design scale shows the

highest result, with a 5.00 mean score for applying the rules and challenges principle and achievement principle. Meanwhile, the multimedia design scores between 4.75 and 4.83 for applying the segmenting principle with user-paced control. Other general principles recommended in the prototype also scored high mean scores, such as 4.83 for visual design that matches learning content and content design that minimises redundancy and provides a question-and-answer format related to the learning content. Furthermore, the participants also agreed to the navigation recommendation where learners can easily choose what parts of the course to access, the order and pace of studying with a 4.75 mean score, and all usability recommendations for the interaction scale have scored high mean scores from 4.83 to 4.92. These results show that integrating gamification and segmenting principles and the proposed general principles into designing interactive gamified assessments for introductory programming courses has been proven effective for low-achieving students. Further discussions with the participants have also been conducted to collect more insightful comments and recommendations for improving the gamified programming assessment. Table 6 summarises the comments recorded from the session.

Table 6. Other comments and recommendations

No	Other comments or recommendations
1	The proposed design manages to provide components and elements that are suitable for low achievers and can be applied in the actual prototype.
2	The game elements chosen are appropriate to boost students' motivation and engagement.
3	Challenges designed for the assessment based on gamification elements (levels, points, and badges) are suitable for low-achieving students.
4	The combination of the multimedia elements is suitable for the low achieving students. However, voice narration can also be included in the assessment design.
5	The gamification principles are suitable; I recommend adding a leaderboard to the game elements.
6	Minimise redundancy, especially for the combination of narration and background audio.
7	Combining images and narration can be optional (learners can turn on/off audio).
8	The assessment levels or challenges are suitable to be applied. However, we need to consider displaying the cognitive level in the assessment section of the prototype.
9	Overall, it is an excellent design to be applied in a learning management system where the consideration is towards low-achieving students who might face challenges in understanding and staying engaged in their learning of programming fundamentals.

The second research question was answered and achieved upon completing the iterative design phase, which consisted of sub-phases of designing the storyboard, high-fidelity prototype development, and user reviews session. All the selected gamification and segmenting multimedia learning principles have been successfully integrated into the design of the gamified programming assessment and received positive reactions from the target users, who are low achievers in introductory programming.

CONCLUSION AND FUTURE RESEARCH

Developing interactive gamified programming assessments customised for introductory programming students with lower academic performance involved a comprehensive series of stages. These stages leveraged gamification principles, such as achievement, progression, and rules and challenges, in conjunction with the segmenting principle, to effectively enhance the learning process for this specific student group. For instance, the incorporation of the rules and challenges principle was manifested in the design through the presentation of narrative-based questions that outlined explicit rules to be adhered to, accompanied by a series of challenges to be surmounted. Likewise, the prototype integrated the progression principle by featuring a user-friendly progress bar, enabling learners to monitor their advancement effortlessly.

Furthermore, applying the achievement principle was instrumental in allowing students to earn badges and accumulate points, representing their overall performance and accomplishments. Additionally, including the segmenting principle within the prototype played a crucial role in promoting self-regulated learning among students. This was achieved by dividing the assessment into smaller, manageable segments and offering user-paced control features, granting individuals the flexibility to complete the assessment at their preferred pace. The general design guidelines incorporated in the design based on Nielsen's design guidelines and Zaharia's usability evaluation framework with motivation to learn also have helped the prototype be more effective, engaging, and motivating. Future research will explore additional gamification principles such as social influence, where research about friending or group quests can be explored in a computer-collaborative learning platform, or the principle of ownership, where students may exchange points or badges to progress into the next level of challenges. Meanwhile, another multimedia learning principle that can also be considered is the signalling principle, which highlights the importance of programming terms or pre-training that helps students become familiar with basic programming concepts before proceeding into advanced programming.

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AUTOMATED WRITING EVALUATION SYSTEM FOR FEEDBACK IN THE DIGITAL WORLD: AN ONLINE LEARNING OPPORTUNITY FOR ENGLISH AS A FOREIGN LANGUAGE STUDENTS

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ABSTRACT

It is imperative to use new technologies in a supportive manner to meet the learners' and teachers' demanding needs as educational environments change in the digital age. The continuous expansion of online learning and distance education opportunities responds to the demands of learners and teachers while pioneering the use of technology in education. One advancement in English language teaching and learning in online environments, which assists teachers in reducing their workload and providing students with instant digital feedback, is the automated writing evaluation (AWE) tools. To gain a deeper understanding of the potential and limitations of these digital tools, this study aims to investigate the effectiveness of AWE feedback in error reduction in writing in English and the explore views of students regarding the utility of AWE tools. For this purpose, a total of 38 students at a university in Turkiye participated in the study, and three of their essays were evaluated. Within a concurrent triangulation mixed-method design, the changes in errors of the experimental group (n=18) receiving AWE feedback, and the control group (n=20) receiving teacher feedback were analyzed quantitatively, and the written reflection reports and semi-structured interviews conducted with the students were analyzed qualitatively. The results indicated that teacher feedback and AWE feedback were both effective in reducing errors in 11 categories. AWE feedback appeared to minimize errors in mechanics and usage more efficiently and teacher feedback was required more in content and organization issues. As a result, AWE was found as a complementary and effective tool supporting the improvement of target language writing skills saving time and energy for teachers. Furthermore, students expressed positive views regarding the use of AWE despite minor limitations. The findings of this study in general sheds light on using online digital tools of ubiquitous nature such as AWE to assist language improvement outside the class.

Keywords: Automated Writing Evaluation system for feedback, Online learning in L2 writing, online feedback in L2 writing, L2 writing evaluation in the distance learning environment, Students' views on digital writing evaluation tool.

INTRODUCTION

In English as a Foreign Language (EFL) contexts, writing skills are fundamental to disseminating information, both inside and outside of the classroom. It is generally considered that writing is the most complex of all language skills (Lerner, 1996; Lombana, 2002), owing to the difficulty of mastering writing skills in an EFL context compared to writing in a native language context (Silva, 1993). While writing in another language (L2), learners generally are engaged in the process of going through numerous stages and cycles of writing to improve their writing skills (Deqi, 2005; Jefferson & Radhakrishnan, 2020); however, instructors face a labor-intensive and time-consuming task in providing immediate and personalized feedback. Hence, there has been an increasing interest in identifying the most efficient and satisfying methods of feedback and error correction. In the digitalized world, providing feedback on students' writing is possible via technological tools and may help to overcome challenges stemming from time constraints and teacher workload in typical EFL classrooms. Recent advancements have made it possible to provide online and e-learning opportunities that would take the heavy burden of the teachers to provide individual feedback to L2 writers regardless of the physical boundaries of the classrooms. Thus, the implementation of digital systems can make it possible for learners to access feedback in less time and effort (Jiang, Yu & Wang, 2020; Zeng, 2020).

Aligned with efforts to identify effective ways to provide feedback and improve writing skills, language education methodology evolves toward a hybrid of traditional and digital technology pedagogy with an emphasis on learner autonomy and self-regulated learning (Huang, Kuang & Ling, 2022). However, without any guidance and direct or indirect correction, students may have difficulty focusing on their writing errors and they may find it frustrating and time-consuming (Nordrum, Evans & Gustafsson, 2013). Thus, online learning opportunities guided by the teachers outside the classroom environments may not only assist L2 learners to focus on their errors but also create a space for gaining autonomy and language improvement.

As a result, current research has focused on the use of online learning technologies and web-based applications that may offer feedback to nurture and support students' learning in the improvement of writing skills with an emphasis on self-regulation. In this regard, integrating Automated Writing Evaluation (AWE) technologies into L2 writing is considered a way to mitigate the difficulties faced by teachers and students. An increasing number of foreign or second language teaching programs utilize AWE systems since they offer quick and diagnostic feedback (Grimes, 2008; Grimes & Warschauer, 2010; Zhang; 2020; Zhang & Zhang, 2018). This study aims at investigating the effectiveness of an AWE system compared to traditional teacher feedback in EFL classrooms and to explore how students perceive the use of such systems in receiving feedback for L2 writing improvement.

Online English Language Learning and Writing Skills

Although the term online language learning is interpreted differently, essentially, it is a form of language learning that happens with little to no face-to-face components, in both formal and informal settings (Ho, 2021; Hockly, 2015). Nowadays, e-learning environments, including exclusive online learning environments and blended learning environments, are becoming more prevalent and widely used in English language learning. Additionally, the sudden eruption of the pandemic became a catalyst for making virtual learning comprehensive via the electronic gateway for language skills. Technology-based activities are now so ubiquitous in English language learning that it is hard to find a class that doesn't use technology (Parvin & Salam, 2015) as a greater level of flexibility and accessibility is provided by online learning (Sari & Oktaviani, 2021). Based on how activities are structured, Felix (2003) asserts that online learning environments can be used to engage students individually or in groups in authentic settings to foster a variety of language skills. When it comes to writing skills, online English language learning environments seem to provide a platform in which alternative writing instruction can be conducted, bypassing the constraints imposed by curriculum, syllabi, session times, and classroom interaction (Tai, Pan, & Lee, 2015). Incorporating visual, auditory, and kinaesthetic learning styles, online learning environments provide each user with active control and more authentic experiences (Radianti, Majchrzak, Fromm & Wohlgenannt, 2020). Furthermore, other advantages of online learning environments are increased flexibility to monitor students' progress, providing automated feedback, and more opportunities to practice their writing. Therefore, online learning opportunities such as online automated writing platforms could facilitate teaching writing, receive effective feedback, and encourage students to improve their writing skills (Geta & Olango, 2016).

Feedback is regarded as one of the most influential factors affecting improvement in L2 writing skills (Hattie & Timperley, 2007; Joughin, 2009) since, without sufficient feedback, anything done or performed would be ineffective (Laurillard, 2013). In the EFL writing context, corrective feedback refers to teachers' attempts to minimize learners' errors (Chaudron,1988) and is an indispensable part of L2 writing since it allows learners to notice the difference between their output and target-like output. Furthermore, it stimulates a change in learners' interlanguage (Ruegg, 2010; Van Beuningen, 2010). Recent research focuses on finding out the effectiveness of different types of feedback along with teachers' and learners' preferences (Ferris & Roberts, 2001). In actual L2 writing classrooms, teachers are generally required to give feedback on all the errors or a large number of aspects. Many studies also show that EFL learners prefer teachers to correct all of their errors and inform them about different aspects of their writing performance (e.g., Amrhein & Nassaji, 2010; Ustunbau & Cimen, 2016).

On the other hand, providing personalized feedback on all errors and aspects is argued to be less practical and time-consuming (Long, 2013; Warschauer & Ware, 2006) given the workload and tight schedules. Hence, as a supplementary or additional way of responding to learners' writing, computer-mediated feedback is offered, and recent studies investigate the potential of electronic/automated feedback in EFL classrooms. One of the advantages of using computer-assisted assessment or innovative forms of assessment is that students can receive timely and repetitive feedback without time and place constraints (Brown & Bull, 2013), while some problems on the adequacy and quality of teacher feedback may occur due to time constraints in classroom settings (Gorgogeta & Vlachos, 2019). Another advantage is the potential of such innovative ways to promote self-regulated learning

while allowing teachers to improve writing instruction and enable them to make decisions regarding writing instruction in a short time (Zeng, 2020). As a result, automated systems in writing evaluation and their use in language learning contexts have become the focus of attention recently.

Automated Writing Evaluation in L2 Writing

AWE is a computer technology that provides immediate feedback and scores on written compositions (Shermis & Burstein, 2013. Nowadays, such software can be used for writing instruction, formative assessment (the process of evaluating learners' knowledge as they learn), and summative assessment (evaluating learners' knowledge at the end of an instructional period or unit) of low-stakes or high-stakes exams (Hockly, 2019). With the advancement of information, communication, and artificial intelligence technology combined with wide access to computers and the internet, researchers have been able to sophisticate the AWE tools, and more AWE products have been designed to contribute to the assessment process of large-scale and high-stakes exams such as TOEFL and GRE (Dikli, 2006). Recently, AWE has become web-based and available to be used in language learning and teaching context for providing individualized feedback on multiple drafts as well as for scoring purposes.

AWE feedback is also goal-oriented as it provides learners the opportunity to monitor their progress throughout their writing process to determine the gap between their current level and the level of writing proficiency that they desire to acquire (Cotos, 2010). Studies on the effects of formative AWE feedback on students' tendency to revise and improve the quality of writing (Chapelle, Cotos & Lee, 2015; El Ebyary & Windeatt, 2010; Warschauer & Grimes, 2008) strongly suggest that AWE feedback can encourage students to revise and improve their writing. For all these features, AWE is associated with self-regulated learning and autonomous learning. Students who receive indirect automated feedback are more likely to try and succeed through trial and error. In this way, automated feedback promotes self-directed learning, and autonomy (Taskiran, Yazici & Aydin, 2022). Additionally, AWE programs' ability to improve students' writing has been the focus of interest. Studies investigating the effectiveness of AWE in an instructional setting (Attali, 2004; Palermo & Thomson, 2018) found that students' writing performances improved in terms of both form and content as a result of AWE implementation. Furthermore, AWE is reported to improve writing quality in many aspects, such as grammar and mechanics and overall linguistic accuracy (Li, Link & Hegelheimer, 2015; Mohsen & Abdulaziz, 2019). In terms of the AWE tools' ability to decrease errors across different categories, usage, and mechanics errors were identified as less challenging to correct (Long, 2013; Ranalli, Link & Chukharev-Hudilainen, 2017).

The literature on the differences between the effects of utilizing AWE feedback and teacher feedback in formative assessment (Cheng, 2017; Khoii & Dorodian, 2013; Wang, Shang & Briody, 2013) indicates that AWE feedback might be more helpful to improve writing in terms of accuracy when compared to teacher feedback. To illustrate, a study conducted by Bulut (2019) in the Turkish EFL context examined the effect of an AWE tool on writing achievement and the findings revealed that even though both traditional and AWE assessments led to enhanced writing achievement, the students receiving AWE feedback achieved higher grades. Likewise, Gencer (2019) investigated how automated feedback affected writing performance in terms of grammar and mechanics, and the findings revealed that automated feedback had positive effects on students' writing performance in the long term as well as in the short term.

AWE is also found effective in providing scaffolding for better writing performance (Cotos, 2010) and ensures active participation of learners in their learning process. In this regard, learners have an opportunity to become more autonomous and intrinsically motivated to take control of their learning (Attali & Powers, 2008; Cotos, 2014; Weigle, 2013). Moreover, a more recent study conducted by Wilson and Czik (2016) investigated the effects of combining teacher feedback with AWE feedback on students writing motivation and the results indicated that students might benefit more from AWE feedback combined with teacher feedback. Investigating learner perceptions towards the implementation of AWE systems in L2 writing instruction may help to find out the strengths and weaknesses of these systems and how they can be used effectively to improve writing skills.

SIGNIFICANCE AND AIM OF THE STUDY

Reported advantages of AWE, such as providing instantaneous, individualized feedback on both form and content and its ability to predict accurate scores (Attali & Burstein, 2006; Elliot, 2003) have attracted the attention of testing companies, schools, educators, and researchers. However, the use of AWE in classroom settings is relatively new; thus, the use and impact of AWE feedback remain to be open to investigation (Ware, 2011). Additionally, since none of these products were designed to be used in EFL contexts, the research on AWE was limited to psychometric studies, and the studies were either mostly carried out by the software developers in laboratories or they were usually conducted in English as Second language (ESL) contexts (Warschauer & Ware, 2006).

Given the impact of the recent pandemic on educational systems worldwide, the study might inform teachers, students, and administrators in their practices on digital teaching and learning. According to Limpo, Nunes, and Coelho (2020), although technological advancements have been utilized for teaching and learning writing, the significance of these tools is better understood due to the pandemic, thereby making the studies conducted on the use of innovative tools for improving writing even more necessary. Moreover, for the new generation of students who are born into technology and labeled as "digital natives" (Prensky, 2001), the integration of innovative tools into education can promote learning and teaching (Gilakjani, 2017; Hsu, 2016) by taking the attention of learners and engaging them in the learning process. As an innovative tool, AWE might meet the needs of the 21st century if the implementation of AWE is supported by teachers' attempts to improve the writing curriculum (Wilson & Roscoe, 2020), and the findings of this study may contribute to the integration of online learning and distance learning opportunities to improve L2 writing skills. The studies examining the efficacy of AWE and the views of learners may provide a better understanding of the potential of using AWE in EFL writing, yet the integration of AWE into the educational setting has not received much research (Balfour, 2013). Based on these insights, the present study aims at investigating the pedagogical potential of AWE in EFL writing instruction by addressing the following research questions:

1. Is there a significant difference in terms of writing accuracy between a group of students receiving AWE formative feedback with a group of students receiving teacher feedback?
2. How do EFL students view the use of AWE in L2 writing?

METHODOLOGY

A concurrent triangulation mixed-methods design was employed in this study. This design involved a single study including both qualitative and quantitative data collection which were conducted at the same time (Creswell, 2009) to cross-validate, confirm, and substantiate the findings within the study and to add to the depth and scope of the findings. Concerning the quantitative dimension of the study, the comparative research design was adopted to address whether there was a difference between AWE feedback and teacher feedback in terms of writing accuracy. Regarding the qualitative dimension of the study, which investigated the students' views on the use of AWE in L2 writing assessment, data were collected through written reflection reports and semi-structured interviews.

Participants and Settings

The present study was conducted at an English Preparatory Program (EPP) of a foundation university in Turkiye. One year of the EPP includes four modules and each module lasts for eight weeks. Each week students receive a total of 25 hours of instruction in English. Four hours are allocated for writing instruction and practice weekly. In the writing lessons, the process approach to writing instruction is integrated and formative assessment is used for both helping students attain the learning objectives. The participants of this study (n=38) were selected through the convenience sampling method since the participants were accessible and voluntary (Dornyei, 2007). A higher education ethical committee approved the study, and the participants signed a consent form assuring their voluntary participation. They were also informed that they could opt out of the study at any time. The participants' age ranged between 18 to 21 years old (18 years old (n=26), 19 years old (n=10), 20 years old (n=1), 21 years old (n=1) respectively). The study took place during the participants' first term in the EPP. For the purposes of the study, two random writing classes were identified as the experimental groups, including 18 participants, and the other two classes were set as the control groups with 20 participants. All the participants were placed at the intermediate level according to a placement test which was taken prior to any exposure to writing instruction and feedback at the beginning of the term. Even though 'repeat students' (the ones who couldn't get the required score from the final proficiency exam the previous semester/year but continued studying in EPP for the following semester/year) were allowed to use AWE feedback, their data were excluded from the data as their level of proficiency might differ at the beginning of this study and their previous exposure to traditional feedback might affect their views.

Instruments

This study investigated the use of AWE in the formative assessment process, and the views of students. Accordingly, both quantitative (AWE tool *Criterion*™ for the evaluation of student essays) and qualitative (reflection reports and semi-structured interviews) data were employed. A group of experts from English language teaching and information and communication technologies was consulted during the development of all instruments for reliability and validity.

The AWE Tool

The AWE tool used in this study was the *Criterion*™ which is a web-based AWE program that was released in 2002. *Criterion*™ can score essays in terms of organization, style, grammar, mechanics, usage, vocabulary use, and lexical complexity and it provides corrective feedback on a variety of error types such as formation errors, punctuation, agreement errors, wrong word, spelling errors, etc. In the study context, teachers provide feedback via a correction code for errors. The AWE tool, on the other hand, provides explanations of the error and offers suggestions for correction. Figure 1. shows how *Criterion*™ as an AWE tool provides feedback on students' errors in comparison with the teacher's feedback.

Error Type	Sample errors from students' essays	Teacher's feedback	Sample AWE feedback
Ill-formed verbs	They always want *to following* the ….	WF	This verb may be incorrect. Proofread the sentence to make sure you have used the correct form.
Missing or Extra Article	*First* reason why internet is beneficial for people is …	^ or X	You may need to use an article before this word. Consider using the article the
	On the contrary, you can meet *new person*, and …		You may need to use an article before this word. Consider using the article a
Punctuation	Money brings *happiness but* reach people …	P	You may need to place a comma after this word
	There are three reasons to believe *that,* internet is the best invention.		You may need to remove this comma

Figure 1. Sample Feedback Provided by Teachers and the AWE System

When compared to other AWE programs and web-based AWE systems, the *Criterion*™ is considered one of the most accurate AWE tools regarding feedback and scoring (Zupanc & Bosnic, 2015). This program provides formative writing assessment, and the students are allowed to use the system to write multiple drafts outside the classroom or use the system for other lessons or personal study as well. The purpose of the study is not to promote any commercial tool but to investigate the effectiveness of AWE in L2 writing. Thus, other similar programs can also be installed and used in different contexts.

Reflection Reports

Weekly written reflection reports were chosen as the data collection instruments to reveal students' experiences through guided reflection questions immediately after they finish writing their essays using AWE feedback. Students were asked to express their ideas and feelings regarding the use of AWE for feedback, and error correction along with the strengths and weaknesses of the AWE tool. Reflection reports were gathered each week considering the possibility that students' opinions would alter over time. 54 written reflection reports were therefore included in the analysis of qualitative data.

Semi-Structured Interviews

To uncover students' opinions on the use of AWE for formative assessment and evaluation purposes in this study, semi-structured interviews with 13 students from the experimental group who regularly used AWE feedback were conducted during the final week. These interviews allowed for a thorough examination of the participants' viewpoints, their justification, and clarification (Galletta, 2013). Students were asked to state their opinions on the use and effectiveness of AWE for feedback and error correction in detail. Moreover, challenges of the digital writing tool, comparison of teacher and AWE feedback, their feedback

type preference, and potential of using AWE in the future were among the questions directed at the students. The interviews were held at appropriate times for the students and each interview approximately lasted 15 minutes. The interviews were transcribed verbatim.

Data Collection Procedures

The study was carried out in the fall term of the 2019- 2020 academic year at four intermediate-level classes. At the beginning of the study, all the necessary permissions were granted by the Educational Testing Service (ETS), to use *Criterion*™ for this study. In the study context, intermediate-level writing instruction and writing practice focused on fundamental principles of writing in L2 and paragraph writing for the first three weeks. During this period, the students received constant corrective feedback and written comments regarding their errors. This step was identical for both groups as the students from the experimental group also needed to be exposed to the teacher's feedback so that they could unveil their experiences with both feedback types and provide information regarding the similarities and differences. In the fourth week, the requirements, and stylistic features of the essay genre (opinion essay) were introduced to both groups. Additionally, the AWE tool was introduced to the experimental group, tutorials provided by ETS were shared with the students, and students were trained on using AWE features. Furthermore, students were provided with their usernames and passwords. In the fifth, sixth, and seventh weeks, both groups wrote opinion essays. The students in the experimental group (n=18) and the control group (n=20) wrote essays on different topics each week and two drafts were written for each topic. Hence, 228 essays including the second drafts were examined in this study. The topics were the same for both the experimental and the control groups each week, and the length of essays ranged between 250 and 300 words. The first and the second essays were written by hand by both the experiment and the control groups to ensure that using AWE feedback to improve writing was the only independent variable of the comparative analysis since changing the writing environment to digital/computer would be another variable. Hence, the original student essays of the experimental group were transformed into digital files and uploaded to the students' accounts and the students were able to display the AWE feedback to write their second draft.

The control group received regularly used error codes and written comments from the teacher to revise their essays, whereas the experimental group received AWE feedback to write their second drafts. Within the same week, both groups received feedback provided for their second drafts as well. The experimental group wrote reflection reports on the AWE feedback they received. At the end of the eighth week, students' thoughts about their experiences with the AWE tool were obtained through semi-structured interview questions.

Data Analysis

To compare the AWE feedback and teacher feedback in error reduction and find out whether there was a significant difference between these two types of feedback in terms of correcting errors, the first and second drafts of essays were treated, respectively, as pre-feedback and post-feedback conditions. The feedback type was considered as the independent variable and to examine the error reduction across drafts, Ferris's model (2006) which focuses on investigating the effectiveness of a feedback type on common errors was adopted.

To find the common errors, the errors on the first drafts of each writing task were counted. To ensure inter-coder reliability, the errors on 30% of the essays were categorized and counted by another experienced instructor. Miles and Huberman's (1994) formula [(consensus)/ (consensus + disagreement) x100] was used and the inter-rater reliability was found .89 indicating high reliability. As a result, a total of 11 error types were included in the comparative analysis. After the common error types were found, the error counts were normalized by using the formula suggested by Biber, Douglas, Conrad, and Reppen (1998) (error count x essay length/ average word count) since essay length was another variation. The error counts on both drafts of the first, the second, and the third essays were normalized to the average of, respectively, 276, 282, and 295 words. Once the error counts were normalized, Shapiro-Wilk, skewness-kurtosis, and histogram graphs were examined to determine distribution. Since the data did not meet the normality assumptions, the Wilcoxon signed-rank analysis was used because when comparing matched pairs of observations, it is the optimal nonparametric test that can be used (Chamberland, Wang & Roessler, 2008), and this test was conducted

to determine the error reduction from pre-feedback to post-feedback within each group. Moreover, Mann-Whitney U analysis was used to determine whether there was a significant difference between the groups according to the post-tests. In the case of non-normally distributed data, this non-parametric test can determine whether or not the medians of two groups differ significantly from one another (McDonnell, Connell, Hannif & Burgess, 2013).

To analyze the students' views on the use of AWE, written reflection reports and interviews were analyzed. In qualitative data analysis, Constant Comparison Method (CCM) which has roots in grounded theory research (Glaser & Strauss 1967) was used. CCM was utilized to interpret categories emerging from codes grounded in data rather than preconceived ones (Charmaz, 2006). A code in this study refers to the words or phrases that stand in for feelings and thoughts and codes disclose participants' perspectives. To create subcategories, the codes were then contrasted and compared both within and between the sets of data. Finally, new subcategories were combined into main categories. To ensure reliability, another experienced rater analyzed the data as well. For inter-rater reliability, the agreement formula [(the number of agreements)/(the number of agreements + the number of disagreements) x100] suggested by Tawney and Gast (1984) was used, and it was found .91 denoting a high level of reliability.

FINDINGS

RQ1: The Change in EFL Students' Writing Accuracy After AWE Feedback and Teacher Feedback

To find out whether the experimental and control groups were similar in terms of writing accuracy at the beginning of the study, the pre-feedback errors of both groups were analyzed. Mann-Whitney U analyses revealed that although spelling errors showed a significant difference in favor of the experimental group ($U = 109.50$, $p < .05$) in the first writing task and spelling errors ($U = 105.50$, $p < .05$) and capitalization errors ($U = 90.50$, $p < .05$) showed a significant difference in the second writing task, there was no significant difference ($p > .05$) between groups in the final writing task before the provision of AWE feedback. Moreover, when Mann-Whitney U analyses of the first drafts are taken into consideration, it can be inferred that the number of errors made by the students in both groups is mainly similar. In other words, there was no significant difference between the groups in most variables examined in the context of the essays ($p > .05$). This situation reveals that before the students in the experimental group were exposed to AWE feedback, the students in both groups were similar to each other in terms of writing accuracy except for spelling errors and capitalization errors on a single occasion.

To determine the accuracy change depending on the feedback type, the Wilcoxon signed-ranks test was conducted to find out whether there was a significant difference in the pre-feedback and post-feedback error counts of the students in the experimental and control groups. This test was conducted to compare both groups' pre-feedback and post-feedback error counts for their first, second, and third essays to identify the exact change according to the feedback type. The results of the Wilcoxon signed-ranks related to the students' essays are presented in Table 1.

Table 1. The comparison of pre-feedback and post-feedback error counts of students' essays

Error Types		The First Essay								The Second Essay								The Third Essay							
		Experimental Group				Control Group				Experimental Group				Control Group				Experimental Group				Control Group			
		N	Mr	Z	p	N	Mr	Z	P	N	Mr	Z	p	N	Mr	Z	P	N	Mr	Z	P	N	Mr	Z	P
Fragment (pre-post)	Nr	8	4,50			12	7,50			12	7,13			12	6,50			13	7,00			13	7,00		
	Pr	0	,00	-2,521	**,012***	1	1,00	-3,111	**,002***	1	5,50	-2,796	,005*	0	,00	-3,064	**,002***	0	,00	-3,181	**,001***	0	,00	-3,181	**,001***
	Ties	10				7				5				8				5				7			
Run-on (pre-post)	Nr	15	8,00			14	8,50			11	6,00			15	8,00			16	8,50			15	8,00		
	Pr	0	,00	-3,408	**,001***	1	1,00	-3,352	**,001***	0	,00	-2,936	,003*	0	,00	-3,411	**,001***	0	,00	-3,516	**,000***	0	,00	-3,408	**,001***
	Ties	3				5				7				5				2				5			
Sentence structure (pre-post)	Nr	12	6,50			11	6,00			6	3,50			7	4,00			11	6,00			9	5,00		
	Pr	0	,00	-3,059	**,002***	0	,00	-2,937	**,003***	0	,00	-2,207	,027*	0	,00	-2,366	**,018***	0	,00	-2,936	**,003***	0	,00	-2,668	**,008***
	Ties	6				9				12				13				7				11			
SVA (pre-post)	Nr	15	8,00	-3,408	**,001***	18	9,50	-3,724	**,000***	13	7,00			15	8,00			12	6,50			16	8,50		
	Pr	0	,00			0	,00			0	,00	-3,180	,001*	0	,00	-3,408	**,001***	0	,00	-3,059	**,002***	0	,00	-3,516	**,000***
	Ties	3				2								5				6				4			
Ill-formed verb (pre-post)	Nr	17	9,00			19	10,00			13	7,00			19	10,00			14	7,50			13	7,00		
	Pr	0	,00	-3,621	**,000***	0	,00	-3,824	**,000***	0	,00	-3,180	,001*	0	,00	-3,823	**,000***	0	,00	-3,296	**,001***	0	,00	-3,180	**,001***
	Ties	1				1				5				1				4				7			
Wrong word (pre-post)	Nr	9	5,00			10	5,50			14	7,50			11	6,36			14	7,50			14	7,50		
	Pr	0	,00	-2,666	**,008***	0	,00	-2,803	**,005***	0	,00	-3,296	,001*	1	8,00	-2,432	**,015***	0	,00	-3,296	**,001***	0	,00	-3,296	**,001***
	Ties	9				10				4				8				4				6			

Table 1. *(Continued)* The comparison of pre-feedback and post-feedback error counts of students' essays

Error Types		The First Essay								The Second Essay								The Third Essay							
		Experimental Group				Control Group				Experimental Group				Control Group				Experimental Group				Control Group			
		N	Mr	Z	p	N	Mr	Z	P	N	Mr	Z	p	N	Mr	Z	P	N	Mr	Z	P	N	Mr	Z	P
Article (pre-post)	Nr	17	9,00			8	4,50			17	9,00			17	9,00			**16**	8,50			10	6,40		,006*
	Pr	0	,00	-3,621	**,000***	0	,00	-2,521	**,012***	0	,00	-3,621	,000*	0	,00	-3,622	**,000***	0	,00	-3,517	**,000***	1	2,00	-2,758	
	Ties	1				12				1				3				2				9			
Preposition (pre-post)	Nr	15	8,00			19	10,00			15	8,00			19	10,00			11	6,00			12	6,50		
	Pr	0	,00	-3,409	**,001***	0	,00	-3,824	**,000***	0	,00	-3,409	,001*	0	,00	-3,824	**,000***	0	,00	-2,934	**,003***	0	,00	-3,059	,002*
	Ties	3				1				3				1				6				8			
Spelling (pre-post)	Nr	13	7,00			18	10,50			13	7,00			18	10,50			15	8,00			16	8,50		
	Pr	0	1,00	-3,180	**,001***	1	1,00	-3,783	**,000***	0	,00	-3,180	,001*	1	1,00	-3,783	**,000***	0	,00	-3,408	**,001***	0	,00	-3,517	**,000***
	Ties	5				1				5				1				3				4			
Capitalization (pre-post)	Nr	11	7,00			16	8,50			11	7,00			16	8,50			10	5,50			9	5,00		
	Pr	1	,00	-2,981	**,003***	0	,00	-3,516	**,000***	1	1,00	-2,981	,003*	0	,00	-3,516	**,000***	0	,00	-2,805	**,005***	0	,00	-2,666	,008*
	Ties	6				4				6				4				8				11			
Punctuation (pre-post)	Nr	18	9,50			20	10,50			18	9,50			20	10,50	-3,921	**,000***	16	8,50			20	10,50		
	Pr	0	,00	-3,724	**,000***	0	,00	-3,921	**,000***	0	,00	-3,724	,000*	0	,00			0	,00	-3,516	**,000***	0	,00	-3,920	**,000***
	Ties	0				0				0				0				2				0			

Based on negative ranks

* Statistically significant ($p < .05$)

Mr: Mean rank

Nr: Negative ranks

Pr: Positive ranks

As observed in Table 1, there was a statistically significant difference in both groups' revisions based on the type of feedback for the first essays ($p < .05$ for all variables). The error counts in both groups were in favor of negative ranks, indicating a reduction in errors. Likewise, in the context of the second student essays, both types of feedback led to a statistically significant reduction in all variables (error types) examined in the experimental and control groups ($p < .05$ for all variables). Furthermore, according to the same analyses conducted for the final writing task, both types of feedback resulted in statistically significant differences in all variables (11 types of error) tested in experimental and control groups ($p < .05$ for all variables). To put it in a nutshell, for both groups, both types of feedback (AWE and teacher feedback) significantly reduced the error counts in each category. In addition to within-groups comparison, between-groups comparison was made using the Mann-Whitney U analysis. Accordingly, whether the type of feedback given to the first drafts of the essays showed a significant difference in the post-feedback scores of the experimental and control groups was examined. The results are presented in Table 2.

Table 2. Post-feedback scores of the experimental and control groups

Writing Tasks (post-feedback)		Experimental (N=18)		Control (N=20)			
		Mean Ranks	Sum of Ranks	Mean Ranks	Sum of Ranks	U	P
The First Essay	Fragment	20,22	364,00	18,85	377,00	167,00	,693
	Run-on	18,00	324,00	20,85	417,00	153,00	,371
	Sentence structure	18,94	341,00	20,00	400,00	170,00	,730
	Subject-verb agr.	17,89	322,00	20,95	419,00	151,00	,210
	Ill-formed verbs	15,89	286,00	22,75	455,00	115,00	,044*
	Wrong word choice	19,61	353,00	19,40	388,00	178,00	,951
	Article	9,78	176,00	28,25	565,00	5,00	,000*
	Preposition	18,75	337,50	20,18	403,50	166,50	,686
	Spelling	18,39	331,00	20,50	410,00	160,00	,465
	Capitalization	18,39	331,00	20,50	410,00	160,00	,357
	Punctuation	13,06	235,00	25,30	506,00	64,00	,000*
The Second Essay	Fragment	19,17	345,00	19,80	396,00	174,00	,849
	Run-on	18,75	337,50	20,18	403,50	166,50	,641
	Sentence structure	18,50	333,00	20,40	408,00	162,00	,534
	SVA	17,67	318,00	21,15	423,00	147,00	,196
	Ill-formed verbs	19,06	343,00	19,90	398,00	172,00	,798
	Wrong word	17,44	314,00	21,35	427,00	143,00	,261
	Article	10,67	192,00	27,45	549,00	21,00	,000*
	Preposition	20,11	362,00	18,95	379,00	169,00	,734
	Spelling	18,22	328,00	20,65	413,00	157,00	,385
	Capitalization	18,94	341,00	20,00	400,00	170,00	,619
	Punctuation	10,72	193,00	27,40	548,00	22,00	,000*
The Third Essay	Fragment	20,42	367,50	18,68	373,50	163,50	,618
	Run-on	17,86	321,50	20,98	419,50	150,50	,319
	Sentence structure	19,22	346,00	19,75	395,00	175,00	,863
	SVA	18,08	325,50	20,78	415,50	154,50	,352
	Ill-formed verbs	17,06	307,00	21,70	434,00	136,00	,152
	Wrong word	19,06	343,00	19,90	398,00	172,00	,809
	Article	12,33	222,00	25,95	519,00	51,00	,000*
	Preposition	17,97	305,50	19,88	397,50	152,50	,578
	Spelling	18,25	328,50	20,63	412,50	157,50	,356
	Capitalization	19,56	352,00	19,45	389,00	179,00	,956
	Punctuation	5,42	277,50	23,18	463,50	106,50	,027*

SVA: Subject-verb agreement. U: Difference between the two rank totals. P: Significance of the difference between the medians

In Table 2, a complete picture can be obtained by observing the sum of ranks. The sum of ranks above shows that the difference across all error types was in favor of AWE feedback. In other words, thanks to AWE feedback, the participants in the experimental group made less errors in their second drafts. As for the error types which reduced significantly, the Mann-Whitney U analysis showed that the error types that reduced significantly were ill-formed verbs, ($U = 115.00$, $p < .05$), article ($U = 5.00$, $p < .05$), and punctuation errors ($U = 64.00$, $p < .05$) in the first writing task. In the second writing task there was a significant difference only in the article ($U = 21.00$, $p < .05$) and the punctuation ($U = 22.00$, $p < .05$) errors between the groups, and for the final writing task, it was determined that there was only a significant difference in the article ($U = 51.00$, $p < .05$) and punctuation ($U = 106.50$, $p < .05$) errors between the groups after different types of feedback was received by the experimental and the control groups. In other words, post-feedback results yielded that in terms of the ill-formed verbs, article, and punctuation error counts, the average of the error counts of the students in the experimental group decreased significantly while the mean scores of the error counts of these error types did not decrease significantly in the control group.

These results revealed that the feedback given by the AWE system in the experimental group was more effective in correcting the ill-formed verbs, articles, and punctuation errors compared to the feedback given by the teacher in the control group. In other words, regarding the comparison made over the post-feedback error counts of the groups, there was a significant difference between the two groups in terms of the reduction in the ill-formed verbs, articles, and punctuation errors. Sample AWE feedback and teachers' feedback provided for ill-formed verbs, articles, and punctuation errors made by the students in this study are available upon request from the authors.

RQ2: EFL Students' Views on the Use of AWE in L2 Writing

As a result of the qualitative analysis of the weekly reflection reports and semi-structured interviews regarding the implementation of AWE in L2 writing, a total of 922 codes were identified. Constant comparison of the codes resulted in 15 sub-categories and five main categories. The students expressed their views on various aspects of the AWE system. The main categories related to students' views on the use of AWE in L2 writing can be seen in Table 3.

Table 3. The main categories related to students' views on the use of AWE in L2 writing

Main categories	N*
Improvement in writing performance	324
Advantageous features	224
Comparison of AWE feedback and teacher feedback	157
Gains in autonomy	115
Drawbacks	102
Total	922

N*: Number of codes

As visible in Table 3, the main categories including the respective codes within each category regarding the participants' views on AWE were: improvement in writing performance (n=324), advantageous features (n=224), comparison of AWE feedback and teacher feedback (n=157), gains in autonomy (n=115), and the drawbacks (n=102). That is, the students expressed some positive views about the AWE tool as it helped them to improve their L2 writing performance (i.e. reducing errors, promoting learning via feedback, and increasing attention on errors), it has various advantageous features (i.e. technical advantages, advantages in the quantity and quality of feedback), it helped to compare teacher feedback and AWE feedback (i.e. helped to see the differences and the similarities of two feedback types and helped to find out the preferred feedback type), it had certain gains in learner autonomy in L2 writing (i.e. independence from the teacher, increased self-correction, self-awareness of strengths and weaknesses, and increased motivation). What is more, the students mentioned several drawbacks of the AWE tool such as the difficulty in correcting certain errors and some system-related problems. In the subsequent sections, each main category along with the related sub-categories is given in detail with direct quotations from students' responses.

Improvement in Writing Performance

The first main category was related to the effect of AWE feedback on improving writing performance. Students expressed their ideas about how the system helped to reduce errors, increased their attention to errors, and promoted learning the language in general. The subcategories under this main category can be seen in Table 4.

Table 4. The subcategories related to the effect of AWE on the improvement in writing performance

Writing performance	Explanatory statements	N*
Reduction in errors	*I corrected most of my errors*	249
Promotion of learning via feedback	*I learned that nouns are followed by articles*	54
Increased attention on errors	*I realized the frequent errors and tried not to make them*	21
Total		324

N*: Number of codes

The majority of the students pointed out that they were able to correct their errors thanks to the feedback provided by the system. Students were able to notice a reduction in their errors with the help of instant and regular feedback provided by the AWE system. Moreover, AWE feedback was found to promote learning a foreign language. The students' statements revealed that they might have reached beyond completing the given task since the feedback they received also resulted in learning gains in terms of language use. Finally, the students also noted that they realized the frequent errors they made, and they paid attention to avoid making the same errors while writing their second drafts and other essays. The excerpts below display students' ideas regarding the effects of AWE on their writing performance:

> *S4: "Thanks to the feedback I received, now I know what kind of errors will occur in my writing, and I try not to make those errors."*
>
> *S2: "I have probably revised the feedback given by the system about a thousand times, I used to a have problem in constructing sentences, and I was structuring sentences much differently than I do know. I have learned how to construct my sentences properly by revising the feedback there many times."*

Advantageous Features of the AWE System

The second main category emerging from students' statements was the advantageous features of the AWE system (n=224). Table 5. displays the sub-categories related to the advantageous features of the AWE system.

Table 5. The subcategories related to the advantageous features of the AWE system

Advantageous features	Explanatory statements	N*
Technical advantages	*You can use the system regardless of time and place*	146
Quantity of feedback	*It finds all the errors and evaluates every aspect of the writing*	42
Quality of feedback	*It provides detailed and explanatory feedback*	36
Total		224

N*: Number of codes

Concerning the advantages of using an AWE tool, the majority of the students mentioned that the system can be used on different devices such as smartphones and computers, and it can be used at any time and anywhere. Hence, the availability of the system and its ubiquitous nature were regarded as an advantage by the participants. Moreover, participants pointed out that receiving immediate feedback allowed them to revise and resubmit their essays a couple of times outside the school. Therefore, receiving immediate feedback was timesaving and encouraged students to write multiple drafts. The participants also noted

they were pleased with the amount of feedback given by the system, and they expressed that the abundant quantity of feedback provided by the system helped them to improve writing accuracy on their second drafts. Another reported advantageous feature of AWE feedback was the quality of feedback. The students found AWE feedback clear and to the point as the system provided detailed explanations along with direct or indirect hints. The following excerpts exemplify students' views on the advantageous features of the system:

> *S1: "It (the AWE system) shows all the errors, and it tells you exactly what category the error falls into. Since it finds all the errors even if it is a missing comma, you can see all of the errors on the system"*
>
> *S5: "I think the system can't overlook errors because it has an established system. On the other hand, teachers might be exhausted while assessing writing.*

Comparison of AWE Feedback and Teacher Feedback

Students reflected on their experiences of receiving teacher feedback and AWE feedback to improve their writing in L2 some similarities and differences between the two types of feedback were reported. The sub-categories related to the comparison of the two feedback types are displayed in Table 6.

Table 6. The subcategories related to the comparison of AWE feedback and teachers' feedback

Comparison of AWE and teachers' feedback	Explanatory statements	N*
Differences between AWE feedback and teachers' feedback	*AWE feedback is instant, teacher feedback is delayed*	88
Similarities between AWE feedback and teachers' feedback	*Both types of feedback are indirect and focused on similar error types*	38
The preferred use of feedback in L2 writing	*We can use AWE feedback in general, but teachers can comment on our ideas*	31
Total		157

N*: Number of codes

In general, the students highlighted some differences between these two feedback types. Some of the differences frequently mentioned by students were that they could only receive teacher feedback in the school environment, and they have difficulty receiving feedback for the essays due to the teachers' workload, the number of students in the class, and the limited class hours. Thus, AWE feedback and teacher feedback were perceived differently due to some challenges and constraints related to the school environment. However, according to the students, the AWE feedback and the feedback given by the teachers focused on similar error types, especially the error types under the grammar, usage, and mechanics categories. The students pointed out that both types of feedback guided them to correct their errors on their own instead of correcting the errors directly. Thus, it can be inferred that both teachers' feedback and AWE feedback can be considered indirect feedback types and were effective in writing improvement. Furthermore, the students expressed that the teachers can guide them better than AWE feedback in terms of content, mainly due to the lack of content-related feedback on the AWE system. Hence, it was revealed that the preferred way to use feedback was a mixed use of AWE feedback and teacher feedback. When students were asked about how they would like to benefit from these two types of feedback, the majority of the students expressed their willingness to continue using the AWE tool in the absence of a writing instructor, especially outside the school for self-regulated learning purposes and to be able to practice writing more.

Gains in Autonomy

Another main category that emerged from the students' statements was related to the positive effects of the AWE tool on gaining autonomy. Automated feedback was found to create self-awareness of the strengths and weaknesses in language use, lead to independency, increase self-correction, and promote motivation. The subcategories of this main category on gaining autonomy can be seen in Table 7.

Table 7. The subcategories related to gains in autonomy

Gaining autonomy	Explanatory statements	N*
Independence from teacher	*We don't need to wait for a teacher to give feedback*	68
Increased self-correction opportunities	*I noticed the areas of improvement and studied accordingly*	21
Self-awareness of strengths and weaknesses	I realized that need to improve my grammar	17
Increased motivation	*Receiving feedback quickly and easily makes you want to practice*	9
Total		115

N*: Number of codes

The students pointed out that, using the AWE tool fostered independence from the teacher. As most of the writing practice took place at school guided by the teachers, students were mostly dependent on the feedback provided by the teachers to improve their writing ability. However, students pointed out that thanks to the ubiquitous nature of the AWE tool, they were able to practice outside the school and they started to feel less dependent on their teacher. Furthermore, it was reported that the system allowed for more self-correction opportunities. The participants stated that the AWE feedback urged them to find out how to correct their errors without direct provision; hence, they had more chances to analyze their errors on their own. Additionally, seeing their errors grouped under certain categories helped them to understand their strength in language use and writing skills, and they were also able to identify the areas for further improvement in their writing. Hence, they realized what they needed to focus on to improve their writing skills. The fourth and final subcategory was an increase in self-motivation to write more and receive more feedback. The following excerpts set an example of participants' views on the aforementioned issues:

> *S1: "In addition to writing essays, I would also use the system for my hobbies. For instance, I like to write stories in English, but since it is something I do outside the school, I can't ask my teachers to correct the errors in my stories. However, I will be able to use the system whenever I need to write in English, so I can also use it for other purposes."*
>
> *S11: "Thanks to easy access to feedback, we were not dependent on the time we spend in the classroom. We were also able to work at home, so we were able to do everything on our own."*

Drawbacks of the AWE System

Albeit various positive views related to the use of AWE in L2 writing, students also expressed some drawbacks of the system. Some difficulties in correcting certain errors and system-related challenges were reported. The sub-categories related to the drawbacks of the AWE tool are displayed below in Table 8.

Table 8. The subcategories related to the drawbacks of using the AWE tool

Drawbacks of AWE	Explanatory statement	N*
Difficulties in correcting certain errors	*I couldn't change some of the repeated words*	74
System-related issues	*The system detected a website name as an error*	28
Total		102

N*: Number of codes

Concerning the drawbacks of the AWE feedback, the students expressed that certain errors were rather challenging to correct compared to others. According to the students, they had difficulty correcting the errors related to the stylistic issues, such as the repetition of words and short sentences. Moreover, some students expressed that the system was not able to identify specific names or concepts in the essays and detected them as errors Thus, it can be inferred that receiving AWE feedback in isolation may not be

sufficient for correcting certain errors, or students may need further writing instruction to improve certain aspects of writing. In addition to difficulties in correcting certain errors, it was pointed out by a few students that they experienced some system-related issues such as the complex features of the interface.

All in all, the findings concerning student views on using the AWE system in L2 writing yielded mainly positive results. Both quantitative and qualitative findings indicated the effectiveness of both AWE feedback and teacher feedback and highlighted the use of AWE not as a replacement for teacher feedback but as complementary support. Albeit some reported challenges, the results of the study, in general, revealed numerous advantages of using an automated digital writing feedback tool that can be used outside the class without time and place constraints.

DISCUSSION

The findings of the study point to the effectiveness of both AWE feedback and teacher feedback in improving L2 writing accuracy. That is, both teacher feedback and AWE feedback led to a significant decrease in writing errors. This concurs well with the previous studies in the literature suggesting that using AWE formative feedback results in positive changes in writing performance by reducing errors (Attali, 2004; Li et al., 2015; Long, 2013; Polermo & Thomson, 2018; Ranalli et al., 2017; Warschauer & Grimes, 2008). In the Turkish EFL context, in a study by Gencer (2019), it was found that AWE feedback had positive feedback on students' L2 writing performances similar to the findings of the present study. The results also revealed better scores in the post-feedback assessment of essays on the behalf of the students who received AWE feedback, a finding echoing Bulut's (2019) study in the Turkish context. The students in the study highlighted the practicality of AWE feedback to save time, instant access regardless of the boundaries of the school context, and receive more feedback for multiple drafts without adding a burden to teachers' workload. Therefore, the findings of the current study support the notion that AWE has great potential in not only guiding students toward improving their writing performances but also reducing teachers' burden of correcting errors in each student's essay regularly and facilitating the assessment process.

Besides the general improvement in writing accuracy, it was ascertained that although both teacher feedback and AWE feedback led to a significant decrease in error counts, there was a significant difference between the two groups in three categories, namely, ill-formed verbs, articles, and punctuation. Hence, the AWE feedback was consistently more effective than teacher feedback in correcting article, punctuation errors and correcting ill-formed verb errors while there was no significant difference between the effectiveness of teacher feedback and AWE feedback in correcting the errors in the other eight categories. In this respect, the findings substantiate other previous findings in the literature. To exemplify, both studies conducted by Khoii and Doroudian (2013), and Wang et al. (2013) reported significant findings in favour of AWE feedback as in both studies the experimental groups significantly outperformed the control groups in writing accuracy. Concerning the error types that AWE was more successful in correcting, the findings of this study correlate favorably with previous studies (Long, 2013; Li et al.,2015; Ranalli et al.,2017, Warshauer & Grimes, 2008) as the findings of the current study further support the idea suggested by Ranalli et al. (2017) that AWE feedback can be more useful to improve form-based aspects of writing and the AWE feedback was more effective on word-level errors and most of the improvement was mainly on grammar and mechanics aspects of writing (Warshauer & Grimes, 2008).

Feedback provided by the AWE system and the teachers for error correction differed in significant ways. To illustrate, while teachers used codes such as '^' for 'article' and 'P' for 'punctuation' to address errors, the AWE tool used in this study specified these errors in more detail by providing explanations and suggestions. Students also reported the effectiveness of such detailed feedback compared to the teachers' feedback. Hence, it can be assumed that although error codes are frequently used to give indirect corrective feedback and are preferred by teachers to save time, students may not understand how to correct these errors and they may need further explanations (Lee, 2003). This finding has insights for L2 writing assessment as it shows that AWE feedback is timesaving, and it may also provide guidance and effective feedback. Although this study did not focus on the effectiveness of AWE on discourse-level writing performance, the findings point to the usefulness of AWE feedback on word-level and sentence-level improvement. Thus, the findings may

suggest that AWE feedback can be used to provide formative corrective feedback on errors, and it can be combined with teacher feedback to ease teachers' burden by allowing them to focus only on the aspects of writing which AWE might disregard or does not provide feedback on. As suggested by Ersanli and Yesilel (2023), while assisting teachers with surface-level errors, AWE tools enable them to focus on content and organization instead of repetitive surfaces-level errors.

Students' views on the AWE system also support the qualitative findings. The present study point to overall satisfaction with the AWE tool and the AWE feedback. The students expressed that they were satisfied with the quantity and the quality of the feedback provided by the system highlighting its various features such as its trustworthiness, availability, and practicality. These views of the students are in parallel with the findings of previous studies regarding students' positive attitudes toward AWE (El Ebyary & Windeatt, 2010, Cheng, 2017; Li et al., 2015; Parra, 2019; Zhang, 2020). One explanation of this can be attributed to students' eagerness to use technology for improving language skills and their need to receive more feedback for language improvement. As suggested by Wang, Chen, and Fang (2011), students' perception of to use of technology in education is parallel with their needs and their familiarity with it.

Another noteworthy finding was that the AWE feedback had positive effects on gaining autonomy. It was expressed by the students that using AWE feedback raised their awareness of their strengths and weaknesses which ultimately increased their learning efforts. Therefore, it can be interpreted that the AWE feedback may have raised students' metalinguistic and meta-strategic awareness which are crucial for a revision stage to be meaningful since detecting errors or flaws in writing and developing strategies improve writing ability (Cotos, 2014). Moreover, regarding gaining autonomy through AWE, the students asserted that using AWE feedback fostered independence from the teacher as they were able to use the AWE system outside the school for many different purposes in addition to the assignments. It is obvious that writing in L2 is one of the most challenging areas for students studying in English-medium programs in the Turkish EFL context (Kamasak, Sahan & Rose, 2021) and providing detailed feedback can be too demanding for English instructors (Gurel, 2010). One implication of the findings might be that the AWE tools can be utilized to promote autonomy, self-regulated learning, and it can be used for various purposes. The AWE tool was also found to increase students' motivation to write more and receive more feedback. The findings regarding the relationship between using AWE and motivation are consistent with previous studies suggesting that AWE tools increase students' motivation to write in L2 and help them revise their writing (Bulut, 2019; Li et al., 2015; Wilson & Czik, 2016; Wilson & Roscoe, 2020) and encourage them to analyze their errors privately by a fast and individualized explanation (Parra & Calero, 2019). Given that intrinsic motivation is believed to be essential to initiate self-regulated learning and promoting learning efforts (Pintrich, 1999; Stone, 2017), the students might have become more motivated as their revisions were more learning-oriented.

Students' reflections on their experiences with the traditional feedback and the AWE feedback yielded that there were some similarities and differences between the traditional feedback and AWE feedback. Some of the similarities reported by the students were the types of error categories and error types for which feedback was provided, the usefulness of both feedback types, and the guidance received by the feedback received from the system and the teacher. Therefore, it can be assumed that AWE feedback is compatible with traditional feedback in leading learners to work on their errors (Calvo & Ellis, 2010). As for the differences, it was mentioned by the students that AWE feedback was more available compared to teacher feedback. However, receiving automated feedback was insufficient in realizing content-related errors. In line with the findings of Zhang and Hyland's (2018) study, these findings indicate that AWE feedback is rather form-focused whereas the teacher's feedback focused more on content and organization. Therefore, when asked what type of feedback they would prefer to receive, the majority of the students expressed their willingness to receive a combination of both feedback types. Similarly, previous studies which investigated the effects of combining teacher feedback with AWE feedback on students' writing motivation (Wilson & Czik, 2016; Mohsen & Abdulaziz, 2019; Palermo & Thomson, 2018) revealed that the students who received a combination of AWE feedback and teacher feedback were more motivated to revise and improve their writing. As a result, this study highlights the effectiveness of using AWE systems along with teacher feedback to improve L2 writing, especially in EFL contexts where students need more feedback and opportunities for correction.

CONCLUSION AND IMPLICATIONS

The findings of the present study highlight the importance of implementing useful and effective online tools that provide effective feedback and error correction opportunities in L2 writing which is of utmost importance in the new era of digitalization that gained momentum due to the current pandemic process. Considering the need for students to get feedback from reliable sources when they are on their own, it is crucial to identify and use effective tools. Therefore, introducing online learning tools such as the AWE is of great importance, especially in EFL writing. As the results of the current study indicate that even though AWE feedback may not replace teacher feedback altogether, it can complement teacher feedback in a way that enables teachers to focus more on global issues of writing such as content and organization. Apart from that, encouraging students to use AWE-like tools outside the classroom as an online learning opportunity can allow learners to become autonomous and have more opportunities to assess themselves and receive feedback on their writing.

Drawn from the aforementioned findings of the current study, some pedagogical implications are that AWE can be used by students during the preparatory year and while continuing their studies at the faculty to check and correct errors and improve linguistic accuracy in written texts, such as assignments and research papers by helping students gain autonomy and engage in self-improvement activities without depending on teachers. One of the implications of this study regarding teachers is that teachers may receive great benefits when assistive technology such as AWE tools are integrated into the summative and formative assessment of L2 writing. By doing so, teachers can reduce their workload significantly, and they can save a lot of time by giving individual or corrective feedback to students on other aspects of writing, such as meaning and organization. In addition, teachers can encourage students to use AWE outside the classroom by assigning writing tasks, as the opportunities for practice and revision in the classroom are limited due to the crowd of the classes and the intensity of the curriculum. Moreover, considering the potential benefits of these systems for teachers and students and the likelihood of popularization of such tools, administrators' attempts to integrate such tools into writing instruction, practice, and assessment will provide great convenience to all users in the future.

Despite favorable findings, the results reported in this study must be interpreted in light of a number of limitations. To illustrate, the time frame of this study was restricted to eight weeks. Hence, a longitudinal study might be designed to explore the issues concerning the implementation of AWE in depth. Moreover, the data were collected from students who were at the intermediate level of English proficiency. Therefore, future studies might need to include other proficiency levels to generalize the findings. Further studies exploring the differences between receiving a combination of AWE and teacher feedback and utilizing either one of these feedback types in isolation might prove important. Moreover, in open and distance learning settings, similar studies can be conducted using AWE. Investigating the effectiveness of a hybrid feedback mode and the views of both students and teachers on combining teacher feedback with AWE feedback might also be explored. Additionally, further studies might explore the relationship between AWE tools and the factors that have great effects on learning such as autonomy and motivation.

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A MIXED-METHODS STUDY OF SCHOOL LANGUAGE TEACHERS' TECHNOLOGY INTEGRATION: ARE THEY COMPETENCE WITH TPACK IN ONLINE LEARNING ENVIRONMENT?

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ABSTRACT

Over the past few years, technology integrated into online learning has become a significant component of education in response to educational evaluation worldwide, especially in Indonesia. The current study aims to explore the TPACK levels of Javanese school teachers, identify integrated technologies-based media used by Javanese school teachers in online learning practices and learning assessment, and analyze the benefits and drawbacks of Javanese school teachers integrating technology in online learning. This study used a mixed-method design, combining quantitative and qualitative approaches. The participants were 330 Javanese school teachers from Central Java Province and Yogyakarta Special Region, Indonesia. The findings reveal that Javanese school teachers are more proficient in pedagogical knowledge, pedagogical content knowledge, and content knowledge than technological knowledge, technological content knowledge, technological pedagogical knowledge, and TPACK. Javanese School teachers have integrated various technologies into online learning. However, Javanese school teachers limited technological literacy affects the efficiency of online learning. In addition, this study also offers an overview of the knowledge and expertise of Javanese school teachers regarding technology mastery in online learning. Thus, this study suggests that policymakers facilitate Javanese school teachers to develop technological skills in transferring materials in online learning to support the current adapted curriculum.

Keywords: Indonesia, integrated technology, Javanese school teachers, online learning, TPACK.

INTRODUCTION

As a result of socio-educational development, technology integration in learning has become an integral and significant part of educational change around the world (Ahmadi, 2018; Akram et al., 2022; Eady & Lockyer, 2013; Hechter et al., 2012; Karchmer-Klein & Konishi, 2023; Paudel, 2021). In Indonesia,

this trend is also reflected in the response to the evolution of the education curriculum that triggers a transformation in teaching and learning approaches, particularly in Javanese language subjects at the primary to secondary school levels. The change in curriculum policy from the 2013 Curriculum to the independent curriculum has encouraged a shift to online learning methods to support student character-building projects at the school level. Several factors trigger this learning model's shift, including the limited time in face-to-face Javanese teaching activities. This condition encourages teachers to adapt online learning methods that can effectively meet the allocation of learning time by utilizing technology to improve the quality and accessibility of learning. Integrating technology in online Javanese language learning can facilitate limited face-to-face teaching in schools (Akram et al., 2021). In addition to providing face-to-face learning opportunities online, integrating technology in teaching improves teaching quality and develops students' skills, increasing motivation, knowledge, and information efficiently (Akram et al., 2021; Chen et al., 2018).

Despite the advantages of using technology in online learning environments, teachers face difficulties utilizing integrated technology in learning practices due to inadequate technological competence (Akram et al., 2022). In addition, the lack of preparation in utilizing practical pedagogical approaches to adapt technology is another challenge for teachers. Teachers are also reluctant to improve their pedagogical competencies and digital skills due to limited learning time. Therefore, some teachers only integrate technology in the online learning of the Javanese language. Several studies (Ariyani et al., 2022; Elmaadaway & Abouelenein, 2023; Fuad et al., 2020; Ginting et al., 2022; Juanda et al., 2021; Kartimi et al., 2021; Kiyici & OVEZ, 2021; Makawawa et al., 2021; Mourlam et al., 2021; Tamah et al., 2020) portrayed teachers' perceptions of TPACK in teaching in various fields in schools during online learning during the Covid times, but overlooked the perceptions of school teachers, especially Javanese school teachers about the level of technological knowledge and technology integrated media in learning and the benefits and drawbacks in online learning. It suggests a gap in the study that this study seeks to address. The following study issues are the primary focus of this study:

RQ1: What are TPACK levels of Javanese school teachers?

RQ2: To what extent do Javanese school teachers' integrated technology-based media in online learning practice and learning assessment?

R23: To what extent do Javanese school teachers benefit and drawback integrating technology in online learning?

By acknowledging Javanese school teachers' perceptions, this study would help to know the extent of their ability to master technology. The aim is to prepare Javanese teachers' competencies to be more technology literate. It is intended that the difficulties Javanese school teachers face in using technology can be identified and proper facilitation can be provided to support the current adapted curriculum.

LITERATURE REVIEW

Studies on Teachers' Levels TPACK

In recent years, studies on Technological Pedagogical Content Knowledge (TPACK) have received increasing attention in various teaching fields. Cakiroglu et al. (2023) assessed the TPACK of teachers from education faculties involved in emergency distance learning and showed that the teachers had a high level of knowledge regarding TPACK. This finding aligns with Saricoban et al. (2019), who mentioned that English as a Foreign Language (EFL) teachers have satisfactory competence in TPACK. Alharbi (2020) also indicated that EFL teachers' TPACK knowledge is generally high. However, an assessment by Jamieson-Proctor et al. (2010) of pre-service teachers in Australia found that although they had high confidence in Technological Knowledge (TK), confidence in TPACK was relatively low, suggesting a gap in their readiness to integrate technology effectively. It is similar to Cheng (2017) in Taiwan, where TK was higher compared to Pedagogical Understanding (PK) and Content Understanding (CK). Zeng (2022) reported that technological knowledge (TK) significantly influences the use of technology by foreign language teachers in the context of Chinese foreign language teachers in Australia. They are more confident in non-technology knowledge compared to technology-related knowledge.

In some countries, the educational context also influences the perception and understanding of TPACK. For instance, Nazari et al. (2019) showed that in Iran, experienced teachers scored higher in pedagogical knowledge and pedagogical content knowledge. On the other hand, Bingimlas (2018) reported that most teachers in Saudi Arabia have a moderate level of TPACK. In addition, Van Loi (2021) reported a moderate level of perception of TPACK among secondary school teachers in Vietnam, mainly related to the challenge of limited access to technology. Muhaimin et al. (2019) found that Indonesian teachers' perceptions of technology-based knowledge tended to be lower than non-technology knowledge. Surayya et al. (2021) showed that most EFL teachers in Indonesia have difficulties in applying TPACK in learning, possibly due to the technology integration constraints faced by senior teachers (Fuad, 2020). Apriandi et al. (2023) also showed that these difficulties are influenced by gender, age, and teaching experience. Consequently, they provide monotonous online learning (Ariyani et al., 2023). Although the teachers are considered to have understood TPACK, there is still a need to improve teachers' technology skills to support the online learning, especially for Javanese school teachers.

The Use of Integrated Technology-based Media in Online Learning

Integrating technologies in online learning has spread worldwide (Hoque et al., 2023; Richards, 2015; Rintaningrum, 2023). The COVID-19 pandemic significantly accelerated the adoption of integrated technologies in educational institutions. Recent research into the different types of integrated technologies school teachers use in online teaching has identified different outcomes, especially in language classes (Zhao, 2015). This study also recognizes the importance of using technology in the language classroom to help school teachers catch up and adapt to new learning styles (Islam et al., 2023). In line with these findings, Bond et al. (2018) concluded that educational institutions should seek to develop future professionals with problem-solving skills, enabling teachers to advance their professional talents by integrating technology into online learning. Not only teachers, but the use of technology can also inspire students, following previous research showing that technology-based instruction can increase students' motivation to learn (Lai & Tai, 2021). Teachers can also improve efficacy and efficiency in online learning by utilizing media-based technology.

The use of technology in digital education has resulted in significant changes in the way to acquire and engage in the process of knowledge acquisition. Technology-based media is vital in this revolution. It includes information and communication technologies, allowing for a more dynamic and diversified teaching experience. Learning management systems such as Moodle, Schoology, and Google Classroom are required within online educational settings (Ariyani et al., 2022). In addition, programs like WhatsApp, Zoom, and Google Forms have been utilized to instruct students in Indonesian (Fuad et al., 2020). A similar trend may be seen in foreign language teaching, where Google Classroom is one of the most often used platforms (Moonma, 2021). Teachers in Indonesia employ a variety of electronic learning platforms to administer online education, encompassing WhatsApp, Zoom, Google Classroom, Edmodo, and additional tools (Tauhidah et al., 2021). In addition, research shows different preferences in platform use by region, with teachers in eastern Indonesia more likely to use Google Classroom and WhatsApp (Maru et al., 2022).

The utilization of Google Classroom, as an illustration, not only expedites the process of teaching and learning but also functions as a tool for evaluating the advancement of students via online assignments and quizzes, fostering active participation in online education (Hussaini et al., 2020). Nevertheless, the inclinations towards electronic learning platforms may differ across various regions of the globe. For instance, widely utilized platforms such as DingTalk, Tencent Meeting, and comparable alternatives are prevalent within China (Chen et al., 2020; Chen et al., 2020). Meanwhile, in other countries, such as India, platforms like Byjus, Vedantu, Whitehat, and Khan Academy have become an integral part of online education at the school level (Kansal et al., 2021). Similarly, in Ukrainian schools, some e-learning platforms are used in educational contexts, such as Accent (Monischool), Class Assessment, and others (Zhenchenko et al., 2022). The use of technology in the realm of online learning has bestowed upon teachers around the globe many options.

Meanwhile, technology-based media integrated into online assessment shows differences with online learning. For instance, Agung et al. (2019) reported that Google Forms is a good choice for teachers as it has advantages in activity, efficiency, and attractiveness for students, which can ease teachers' workload in assessment (Sari et al., 2020). In addition, Divayana et al. (2021) found that SEVINA & EDLink platforms

are one of the online assessment options in the context of online learning in Indonesia. Hidayad et al. (2023) suggest that Kahoot is an appropriate online assessment platform for EFL classes. It is in line with Kusuma (2022) noted the use of Kahoot as an online assessment tool by EFL teachers in rural schools in Indonesia. Aina & Ogegbo (2021) reported various teaching and assessment methodologies used on this platform, such as small group work, collaborative learning, case method, discussion posts, multiple-choice quizzes, chat, game activities, and open-ended questions.

Benefits and Drawbacks of Online Learning

Online learning has garnered substantial recognition as a feasible substitute for conventional in-person instruction, especially within online education. Despite the numerous benefits of online learning, it also entails certain disadvantages that necessitate careful contemplation. One of the principal advantages of virtual online learning lies in its adaptability and accessibility. As Mukhtar et al. (2020) discovered, online learning is a flexible and practical resource that empowers students to become self-directed learners. By participating in online discussions and activities, students can transcend geographical constraints and enjoy enhanced convenience and flexibility in their educational endeavors. Gilakjani (2014) has demonstrated the benefits of incorporating technology in language teaching and its positive effects. Technology incorporation into language teaching offers excellent chances for students and teachers to explore new things (Merzifonluoglu & Gonulal, 2018). Consistent with Rintaningrum et al. (2016), having access to technology at home makes it simpler for language learners to acquire the language. Additionally, with the aid of technology, language learners can locate various authentic materials that can help them advance their language proficiency (Clements & Sarama, 2003).

On the contrary, one primary drawback of online education is the lack of nonverbal indications. Within in-person interactions, nonverbal cues such as countenances, bodily gestures, and vocal inflections are pivotal in communication and comprehension. In online learning, these cues are often limited or absent, making it challenging to interpret and accurately perceive communication's emotions, intentions, and nuances (Picciano, 2017). The absence of physical presence and reliance can create a barrier to building personal connections and a sense of community. This lack of social presence may negatively impact motivation, engagement, and a sense of belongingness. Similarly, Sepulveda-Escobar & Morrison (2020) found that the lack of direct interaction with learners and sudden changes in setting affected the learning process. Engaging in online learning necessitates a reliable internet connection and appropriate technological infrastructure. Students with limited internet connections or face restrictions in accessing technology might encounter difficulties fully engaging in online discussions and tasks. Technical challenges can disrupt the interaction flow and hinder the learning experience (Hrastinski, 2008). In line with Kamal & Illiyan (2021), they encountered obstacles in online learning, such as technical constraints, difficulties in examinations, and online assessments.

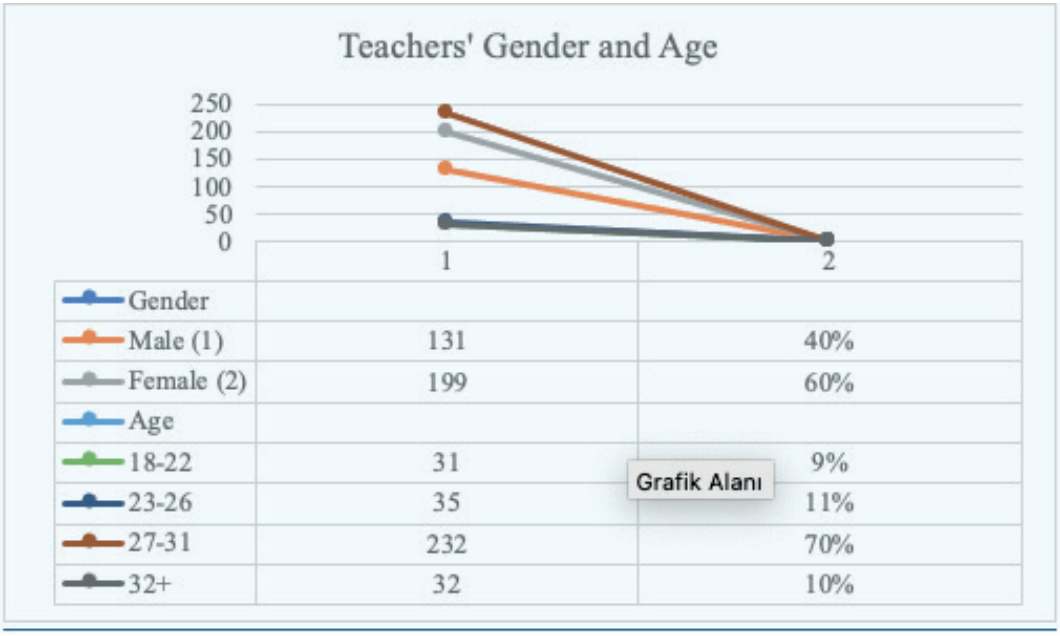
METHODS

This comprehensive research study used a mix method research design, combining a quantitative and qualitative approaches (Creswell, 1999). This research design effectively integrated the strengths of each method to offer a comprehensive understanding of the study topic. The study employed several clear steps, from preliminary research, instrument development, survey implementation in Central Java and Yogyakarta Special Region, data analysis and synthesis, and reporting of results, to ensure a systematic and holistic approach.

Participants

The subjects were Javanese school teachers in Central Java Province and Yogyakarta Special Region, Indonesia who were selected by random sampling. The data collection technique used a questionnaire distributed through the Google Form. The target subjects were 330 Javanese school teachers in primary schools, middle schools, high schools, and technical colleges, both public and private. The 330 Javanese school teachers were divided into 40% male and 60% female teachers. The age range of respondents ranged from 18 years to more

than 32 years, with 9% of teachers aged 18-22 years, 11% of teachers aged 23-26 years, 70% of teachers aged 27-31 years, and 10% of teachers aged more than 32 years. The demographic distribution of the research subjects is presented in Figure 1.



	1	2
Gender		
Male (1)	131	40%
Female (2)	199	60%
Age		
18-22	31	9%
23-26	35	11%
27-31	232	70%
32+	32	10%

Figure 1. Teachers' gender and age

Regarding school level, 9.39% of the participants were elementary school teachers, 40.61% were junior high school teachers, and 50.00% were a combination of high schools, and technical colleges teachers. Figure 3.2 shows the distribution of teachers' length of teaching the Javanese language at each school level. Most of the teachers in this study have been teaching for 3-10 years, with a percentage of 35.2% teachers teaching for 3-5 years and 35.5% teachers teaching for 6-10 years. The rest, 21.8% of teachers, have been teaching for 1-2 years, fresh graduates who have not taught for one year are 5.5%, and senior teachers who have taught for more than ten years are 2.1%. The number of participants who have been teaching for more than three years certainly impacts the pedagogical ability of teachers in teaching Javanese, especially with the challenges of the times that require teachers to integrate technology into Javanese language learning.

	< 1 year	1-2 year	3-5 year	6-10 year	10+ year
Elementary School	5	15	2	6	3
Junior High School	4	28	48	51	3
Senior High School	9	29	66	60	1
Percentage	5,5%	21,8%	35,2%	35,5%	2,1%

Figure 2. Schools and years of teaching

Research Instrument

The 33 items in the study's questionnaire, which were created based on teacher TPACK indicators, had four response scales: strongly disagree, disagree, agree, and highly agree. The statements were modified based on the findings from the questionnaire developed by (Schmidt et al., 2009). Meanwhile, four open-ended statements relating to Javanese school teachers' opinions on Javanese language online learning were adapted from the study and literature (Fuad., 2020; Prior et al., 2016; Shulman, 1986).

Validiy and Reliability

The study instruments were tested for validity and reliability. Validity was tested using the Pearson correlation formula, and all statement items were considered valid because the correlation value was more significant than the r table value at the 0.05 significance level with a sample size of 330. Furthermore, the instrument's reliability was tested using Cronbach's Alpha formula. The resulting values show that each questionnaire item has a value of more than 0.6, which indicates that the questionnaire used is reliable. Before conducting confirmatory factor analysis (CFA), the data verified for validity and reliability were tested for factor eligibility using KMO and Bartlett's Test. KMO values of more than 0.5 and Sig (significance) values of less than 0.05 indicate that the data are eligible for factor analysis.

Data Analysis

The analysis of close statements from the online questionnaire was quantitatively examined using the CFA approach. In order to determine whether there is a correlation between the TPACK variables, the Pearson correlation test was also performed using SPSS version 23.0. Meanwhile, the open-ended questions in the questionnaire were qualitatively examined, with the data being condensed to obtain representative themes, which were then displayed in a table and omitted from the conclusion.

FINDINGS

TPACK Levels of Javanese School Teachers

The results of Javanese school teachers' TPACK skills in online learning have a positive trend by measuring seven TPACK variables. Pedagogical knowledge, pedagogical content knowledge, and content knowledge are the variables that have the most positive trend compared to other TPACK variables. It shows that Javanese school teachers are more expert in mastering the material and can manage the class in delivering effective Javanese language materials. On the other hand, variables concerning technological skills, be it technological knowledge, technological content knowledge, technological pedagogical knowledge, and TPACK, still require further skill development because they have a higher negative tendency (Disagree-Strongly Disagree < 17.1%). It must be noted that teachers have a positive tendency to master theories and how to deliver subject matter but lack mastery of technology to present material, develop students' knowledge related to Javanese language material, and master technology to teach Javanese language more effectively. Mastery of Javanese language materials tends to be more optimistic than mastery of technology because most of the respondents in this study have been teaching for more than three years, so they have a lot of experience and teaching expertise in their fields.

On the other hand, related to mastery of technology, Javanese school teachers find it challenging to develop various types of learning media that utilize technology. The teachers feel that they do not have enough time to explore their abilities, so most of them only use the material in the form of PowerPoints that have been designed in previous years, whereas to support the online learning process where not all material can be taught during the specified lesson hours, technology plays a vital role so that learning can be conditioned optimally. It is reinforced by policies related to the Indonesian Minister of Education and Culture target, which targets increasing technology mastery for teachers. Digital literacy must be a particular concern so that Javanese school teachers want to learn quickly to face technological challenges in the era of disruption 4.0 and education 5.0.

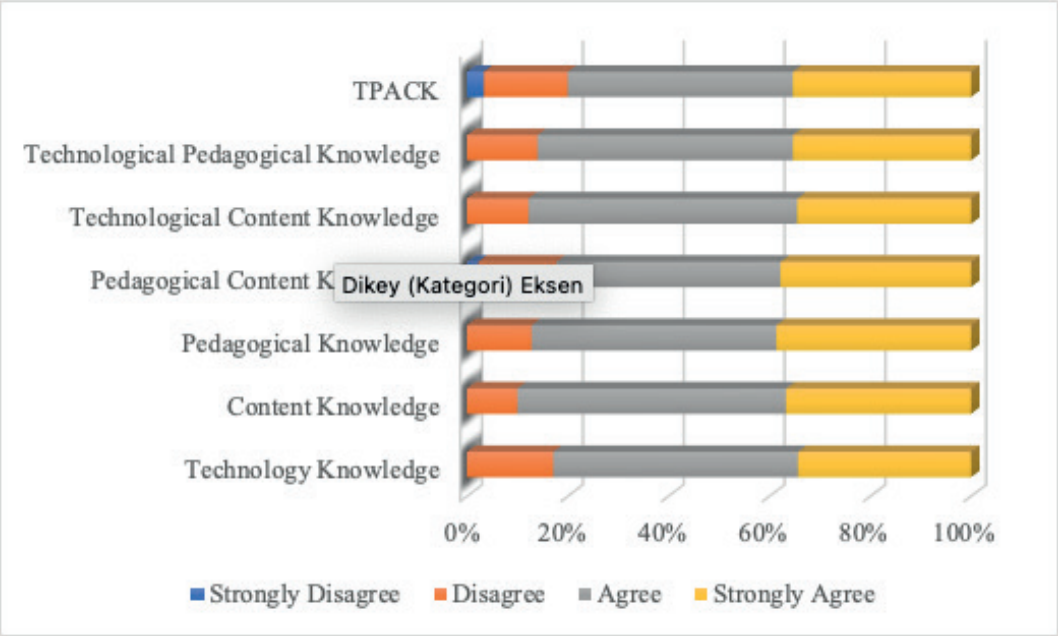


Figure 3. The trend of the variable levels of Javanese school teachers' TPACK

The questionnaire of understanding the mastery of technology manifested in understanding TPACK consists of 33 statement items. Based on Table 1, each TPACK component has factor loading, and judging from the results of Cronbach's Alpha reliability value, which is more than 0.6, the instrument used looks valid and reliable to be used as a research instrument. However, some items have commonalities extraction values of less than 0.5, which indicates that some items do not represent the measured TPACK factors.

Table 1. Responses of frequency and loading factor of TPACK questionnaire

No	Questionnaire Components	Frequency Response				Factor Loading	Cronbach's Alpha	Communalities
		SD	D	A	SA			
	Technology Knowledge (TK)							
1	I know how to handle technical difficulties in the classroom.	0	41	135	154	0.568	0.923	0.323
2	I can use technology easily.	0	58	173	99	0.934	0.894	0.873
3	I remain up-to-date with new technologies that matter to me.	0	52	124	154	0.742	0.905	0.55
4	I like to try new technology.	0	49	182	99	0.667	0.914	0.445
5	I am quite knowledgeable about several technologies.	0	68	174	88	0.85	0.899	0.722
6	I am technically capable of using the technologies.	0	50	181	99	0.904	0.899	0.817
7	I have quite a few opportunities to work with various technologies.	0	77	154	99	0.8	0.905	0.639
	Content Knowledge (CK)							
8	I am knowledgeable enough in Javanese subject.	0	11	220	99	0.711	0.879	0.505
9	I usually apply scientific thinking.	0	33	176	121	0.999	0.662	0.999
10	I use a range of methods and techniques to deepen my grasp of Javanese material.	0	55	132	143	0.792	0.821	0.628
	Pedagogical Knowledge (PK)							
11	I am aware of how to evaluate the work of students in a classroom.	0	11	165	154	0.811	0.948	0.658

12	I can modify my teaching based on what the students currently understand or don't understand.	0	55	154	121	0.852	0.944	0.727
13	I am able to modify my teaching methods for various students.	0	77	132	121	0.937	0.941	0.878
14	I have several approaches to evaluate students' learning.	0	55	154	121	0.836	0.946	0.699
15	I am capable of utilizing a variety of teaching strategies in the classroom.	0	55	176	99	0.904	0.944	0.817
16	I am knowledgeable about the understanding and misunderstandings of students.	0	11	176	143	0.79	0.952	0.625
17	I know how to arrange and organize the class.	0	33	165	132	0.906	0.943	0.821
	Pedagogical Content Knowledge (PCK)							
18	I may choose efficient teaching strategies to direct students' learning and Javanese thinking.	11	88	143	88	0.958	0.444	0.917
19	I can choose a useful teaching strategy to direct students' literacy-related thinking and learning.	11	44	165	110	0.856	0.479	0.732
20	I may modify my teaching methods based on the students' understanding to help them think critically and learn Javanese.	0	22	132	176	0.341	0.9	0.117
	Technological Content Knowledge (TCK)							
21	I am familiar with the technology I can use to study and practice Javanese language materials.	0	44	165	121	0.887	0.935	0.787
22	I can choose the most useful technology to comprehend Javanese language content.	0	44	176	110	1	0.862	0.999
23	I am aware of how to set up and run the lesson while utilizing technology to help students understand the Javanese language curriculum.	0	33	187	110	0.879	0.94	0.773
	Technological Pedagogical Knowledge (TPK)							
24	I can choose technologies to help me teach effectively.	0	44	165	121	0.855	0.903	0.731
25	I am able to choose technology that improves student learning.	0	55	154	121	0.792	0.918	0.627
26	I have given the impact of technology on my teaching style in the classroom a lot of thought thanks to programs in teacher education.	0	33	154	143	0.852	0.907	0.726
27	I consider using technology in the classroom thoughtfully.	0	66	187	77	0.837	0.907	0.701
28	I can modify how I use technology to fit various educational activities.	0	33	176	121	0.885	0.898	0.783
	Technological Pedagogical Content Knowledge (TPCK)							
29	I may teach a suitable subject by utilizing Javanese resources, technology, and teaching strategies.	11	66	110	143	0.968	0.939	0.936
30	I can choose teaching tools that will improve what I teach, how I teach it, and what the students learn.	11	44	187	88	0.76	0.957	0.577
31	I am able to apply the integration techniques I learned in my classroom courses for content, technology, and teaching methods.	11	77	121	121	0.955	0.941	0.912
32	I can help others plan how material, technology, and instructional strategies will be used in my school and/or district.	11	66	154	99	0.9	0.938	0.811
33	I can choose a piece of technology to improve a piece of content.	11	22	165	132	0.875	0.945	0.766

According to Table 1, the values for the Extraction Sums of Squared Loadings for the seven factors examined—TK, CK, PK, PCK, TCK, TPK, and TPCK—show that there is only one-factor variance among the seven factors. Meanwhile, the Eigenvalues show that TK has the most significant contribution, amounting to 58.456% of the overall factor. This result shows that knowledge of technology is essential for Javanese school teachers to learn more effectively by using technology to support learning.

From the correlation test results, despite TK contributing the most to teachers' TPACK skills, each TPACK variable has a positive relationship, including TK, CK, PK, PCK, TCK, TPK, and TPCK variables. It can be seen from the Sig value <0.01, which means that each variable is related. Generally, the correlation coefficient between factors with a score of more than 0.5 can be interpreted as a positive form of correlation between factors. The TK variable has a moderate correlation with the CK, PCK, TCK, TPK, and TPCK variables and has a strong correlation with the PK variable. The CK variable has a moderate correlation with the TK, PCK, TCK, TPK, and TPCK variables and strongly correlates with the PK variable. The PK variable strongly correlates with the TK, CK, PCK, TCK, and TPK variables and has a moderate correlation with the TPCK variable. PCK variable has a moderate correlation with TK and CK variables and strongly correlates with PK, TCK, TPK, and TPCK variables. The TCK variable has a moderate correlation with TK and CK and has a strong correlation with PK, PCK, TPK, and TPCK variables. The TPK variable has a moderate correlation with the TK and CK variables and has a strong correlation with the PK, PCK, TCK, and TPCK variables. The TPCK variable has a moderate correlation with the TK, CK, and PCK variables and has a strong correlation with the PCK, TCK, and TPK variables. Thus, it can be concluded that TPACK variables are interconnected and support each other.

Table 2. Correlation of TPACK components

	TK	CK	PK	PCK	TCK	TPK	TPCK
TK	1	0.653	0.888	0.578	0.643	0.643	0.517
CK	0.653	1	0.713	0.614	0.559	0.501	0.579
PK	0.888	0.713	1	0.704	0.718	0.737	0.618
PCK	0.578	0.614	0.704	1	0.821	0.855	0.897
TCK	0.643	0.559	0.718	0.821	1	0.883	0.851
TPK	0.643	0.501	0.737	0.855	0.883	1	0.905
TPCK	0.517	0.579	0.618	0.897	0.851	0.905	1

The Integrated Technology-based Media Used in Online Learning Practice and Learning Assessment

The use of technology and internet access are highly supportive in increasing the effectiveness of online classes organized by Javanese school teachers to support learning time. Various types of media, applications, and learning platforms are used to teach and learn online. Figure 4.1 shows 16 types of Javanese language media, applications, and learning platforms teachers use during Javanese language learning. Most of the Javanese school teachers who were respondents in the study used PowerPoint as the primary media to deliver Javanese learning materials. The YouTube platform is the second most used media to strengthen students' understanding of Javanese language materials. It is not surprising because students need to get many examples and illustrations of material that is more interesting and easily accessible independently to support Javanese language learning at home. The Google Classroom platform ranks third as technology teachers widely use to share materials and provide assignments to students.

Platforms like Moodle that can be developed as a learning website and have various benefits are less attractive to Javanese school teachers. It can happen because not all schools develop learning websites that can be accessed and used by teachers and students to support the learning process in the classroom. In addition, the ability of Javanese school teachers to develop new learning media that is interesting and according to the characteristics of students also looks still low by looking at the percentage of the use of media Canva, Adobe Photoshop, Adobe Flash, Macromedia Flash, Corel draw, Prezi, including Instagram which incidentally is one of the trending social media accounts among students. Of the sixteen media, only some types of familiar media are often used by Javanese school teachers, while others are rarely used.

On the other hand, using technology is essential in the online learning process and learning assessment. The media and platforms teachers use are Google Form, Kahoot, Quizizz, Wordshare, Wonderwall, Proprof, and MsOffice. Of the seven different learning assessment media, applications, and platforms, most Javanese school teachers (63.03%) use Google Forms as the most accessible and easy-to-use mode of Javanese learning assessment. Ms. Office ranks as the second most used learning assessment technology, at 23.64%. Quizizz game application ranks third as an assessment platform used by Javanese school teachers, at 7.88%. Quizizz, with more accessible features and more stable internet network access than Kahoot, makes it a game application more widely used by Javanese school teachers as an assessment technology for learning Javanese. Other types of game applications such as Wonderwall, word share, and Porprof are still rarely used by Javanese school teachers, even though these applications tend to provide more varied types of assessment games than Quizizz and Kahoot, which require a subscription to be able to optimize various features in them.

Benefit and Drawbacks of Javanese School Teachers in Online Learning

The questionnaire given to Javanese school teachers included open-ended questions that gathered information on the benefits and drawbacks of employing technology in online learning. The Javanese school teachers' response data related to the benefits and drawbacks of using technology written down are then reduced to be grouped into several representative statements, which are illustrated in Table 3.

Table 3. Benefits and drawbacks in Javanese language online learning

Characteristics	Javanese School Teachers' Responses
Benefits	Technology-based media can make it easier for students to learn anytime and anywhere without being limited to space and learning hours in the classroom, so that lessons that are sometimes forced to be reduced do not become a problem for teachers to complete the delivery of material outside the set lesson hours.
	Students can explore various Javanese language material information more efficiently and widely through various websites independently, primarily due to the limited Javanese language textbooks provided by the school.
	The use of various technology-based media makes students and teachers not afraid of being outdated because both parties learn to develop themselves occasionally.
	It makes it easier for teachers to design lessons and administratively carry out the evaluation process.
	Technology makes it easy for teachers to automatically correct students' assignments and test results through the learning assessment platform provided.
	Students can learn according to their learning style, so that the absorption of knowledge and understanding of each student can be maximized.
	Students can learn to be disciplined in submitting assignments on time.
Drawbacks	Many Javanese lessons were not delivered due to time constraints.
	Teachers' limited ability to master technology (ICT) causes learning to occur less effectively.
	Not all students understand technology well, so teachers need sufficient ICT skills to guide students to learn using technology-assisted media.
	Lack of time for self-development due to tasks other than teaching.
	Not all schools have Wi-Fi network facilities, and not all students have enough data packages to access materials connected to the Internet.

Javanese language online learning implemented by most teachers in Indonesia, particularly in Central Java and Yogyakarta Special Region, is a responsive solution to the changing times and technology. Online learning has many benefits for teachers and students, as mentioned in Table 3. One of the benefits online learning offers is the flexibility of time and place. P5 activities that take up much time for Javanese lessons can be dealt with using the online learning model so that the truncated lesson hours at school can be replaced outside formal school hours with the help of technology. The existence of technology balanced with adequate mastery of ICT skills will also make it easier for teachers and students to access additional material with a broader perspective through the internet. The positive thing that will be obtained is students' increasing digital literacy skills so that they will not be afraid of being outdated. Technology, which is the primary determinant of online learning, can also be explored by teachers to provide various technology-based learning media that suit students' characteristics. Thus, students' understanding of the material can be optimized. Teachers can also more easily work on learning administration, starting from designing learning tools to conducting evaluations with the help of technology. In the end, online learning supported by good ICT skills will make the course of Javanese language learning one step ahead of the previous times.

Although it is a benefit, using technology in this online learning does come with certain implementation issues, which are stated in Table 3. One of the main drawbacks is the significant time limitation in implementing online learning. This is because not all students have good internet access, plus not all students come from middle to upper-middle-class families, so many object to having to buy a large amount of internet quota packages constantly. Another drawback comes from the limited human resources of teachers who want to learn to improve their ability to master ICT in learning. Teachers must be willing to learn technological literacy in order to help students use technology as a learning tool. The low ability of teachers to master ICT will undoubtedly have an impact on the ineffectiveness of the learning process.

DISCUSSIONS

This study highlights Javanese school teachers' perceptions of technology integration related to TPACK in the online learning environment. This study investigates 330 Javanese school teachers who used modern technology in their online classes to explore their perceptions. The findings indicate that Javanese school teachers' perceptions have positive trends in pedagogical knowledge, pedagogical content knowledge, and content knowledge rather than technological knowledge, technological content knowledge, technological pedagogical knowledge, and TPACK. In contrast with recent studies, teachers are more confident in their non-technology knowledge than in technological knowledge (Cakiroglu et al., 2023; Muhaimin et al., 2019; Nazari et al., 2019; Santos & Castro, 2021). These findings contrast with some scholars who found that only TK is higher compared to PK and CK (Cheng, 2017; Jamieson-Proctor et al., 2010; Mashhadi et al., 2023; Zheng, 2022). These findings suggest that teachers have a positive tendency to master the theory and how to deliver the subject matter but lack the technology to present the material, develop students' knowledge related to Javanese language materials, and master the technology to teach Javanese more effectively. However, teachers' skills in integrating technology into online learning still need to be improved.

The lack of technology mastery among Javanese language school teachers significantly negatively impacts Javanese language online learning. It is reflected in the survey results showing that Javanese language teachers prefer using learning applications such as PowerPoint, YouTube, and Google Classroom in delivering materials to their students. This choice is because these three media are considered the easiest to use, are well-known by teachers, and do not require extensive data quotas. It aligns with Ariyani et al. (2022) and Fuad et al. (2020), who found Google Classroom as the dominant platform for delivering materials in Lampung Language and Indonesian Language lessons. Teachers widely use the Google Classroom platform for its ease of use, stability, and rich features that meet various learning criteria, such as assignments, quizzes, and end-of-semester exams. It contrasts to Zhenchenko et al. (2022), who found media use in Ukrainian schools such as Accent (Monischool), Class Assessment, and others. In contrast, Kansal et al. (2021) reported that schools in India use media such as Indian platforms like Byjus, Vedantu, Whitehat, and Khan Academy.

Meanwhile, Javanese school teachers also use integrated technology-based media for online learning assessment of the Javanese language, namely Google Forms, Kahoot, Quiz, Wordshare, Wonderwall, Proprof, and Ms. The findings show that Google Forms is still considered the most practical tool to assess students'

learning outcomes during online learning because it simplifies the process of compiling results from all students. Similarly, Agung et al. (2019) assessed that learning assessment using Google Forms is a good choice for teachers because it has advantages in activity, efficiency, and attractiveness for students. In this case, teachers do not feel the need to assess learning outcomes manually, especially if the questions given are in the form of multiple choice. In other words, using Google Forms lightens the teacher's workload regarding assessment (Sari et al., 2020). In contrast, Divayana et al. (2021) found that SEVINA & EDLink platforms are one of the online assessment options in Indonesia's online learning context. Hidayad et al. (2023) showed that Kahoot is an appropriate online assessment platform for EFL classes. Kusuma (2022) noted the use of Kahoot as an online assessment tool by EFL teachers in rural schools in Indonesia.

Despite the integration of technology-based media used by Javanese school teachers, Javanese language learning is ineffective in the long run-in supporting government programs in building student character due to the lack of teacher-student interaction. The teaching approach implemented in Javanese language online learning is less interactive and tends to focus on unilateral delivery of materials. Most Javanese school teachers only deliver materials through PowerPoint, video links, or quizzes sent through WhatsApp, without adequate online interaction. Direct interaction between teachers and students utilizing the Zoom feature is minimal. The lack of online interaction through features such as Zoom can be caused by several factors, one of which is the relatively expensive internet costs. It can be a major obstacle, especially for students or individuals with financial limitations. This approach may not be optimal for language learning, especially Javanese, as languages require interactive exercises, active conversations, and immediate feedback for effective development. This lack of direct interaction has a negative impact on the learning process, as students get less opportunity to ask questions, discuss, or get direct feedback from the teacher. It can also reduce students' motivation and engagement in online Javanese language learning. Similarly, Sepulveda-Escobar & Morrison (2020) found that the lack of direct interaction with learners and sudden background changes affect the learning process.

The implemented approach is due to the drawbacks faced by Javanese school teachers in designing learning media with new technology and several other issues such as time constraints, limited human resources, students' lack of understanding of ICT, limited time for self-development, limited internet access, plagiarism, and the difficulty of measuring students' psychomotor competencies. In contrast, Fuad et al. (2020) stated that online learning is highly dependent on the signal and connection of each user, where not all areas have a good signal, so communication does not work. Technical challenges can disrupt the interaction flow and hinder the learning experience (Andiyan et al., 2021; Dewi et al, 2021; Dutta & Smita, 2020; Hrastinski, 2008). However, online learning does not always provide problems or drawbacks. Conversely, various benefits can be obtained in online Javanese language learning, including flexibility, access to information, self-development, efficient learning, automatic correction, and student discipline. Consistent with Mukhtar et al. (2020) found that online learning is a flexible and practical resource that allows students to become independent students. However, student independence built by teachers in online learning in the absence of face-to-face interaction that only relies on delivering materials and assignments via WhatsApp can have several impacts that need to be considered. One of the impacts is the lack of opportunity to interact directly with teachers and classmates, which may hinder the development of student's social skills and communication abilities. Furthermore, the absence of comprehensive oversight and guidance by teachers can challenge certain students to comprehend the subject matter or accurately fulfill their assignments. Consequently, further endeavors are imperative to uphold the caliber of virtual education, including utilizing a more engaging educational platform and allocating time for online discourse and consultation with instructors. Hence, pursuing Javanese language learning online can yield substantial benefits for teachers and students in enhancing their proficiency.

CONCLUSION AND LIMITATION

This study examines Javanese school teachers' perceptions of integration technology related to TPACK in online learning environments in Indonesia, particularly in Central Java and Yogyakarta Special Region. The quantitative findings illustrate that the perceptions of Javanese school teachers manifest a positive inclination in three fundamental aspects: pedagogical knowledge, pedagogical content knowledge, and content knowledge, in contrast to three dimensions of technological knowledge: technological content knowledge, technological pedagogical knowledge, and TPACK. The results also show that teachers' ability to integrate

technology is still limited, with most technology use still limited to the primary level. The qualitative results illuminate the fact that the utilization of online education in the Javanese language has proven ineffective due to the deficiency in virtual engagement between teachers and students. Implementing online learning in Javanese still has drawbacks related to the teaching approach used by most Javanese school teachers. It is also influenced by the lack of knowledge of Javanese school teachers regarding integrating technology into online learning. Nevertheless, online Javanese language learning can help overcome the shortage of lesson hours in conventional classes.

The acknowledgment of the limitations that exist in this study is crucial for the researchers. This study specifically focused on the perceptions of Javanese school teachers in the Central Java and Yogyakarta Special Region. This demographic limitation could potentially impact the results of this study for teacher populations in other regions of Indonesia. While previous research has examined online education in Javanese, our findings highlight an unresolved issue. Based on the results, the absence of online involvement between teachers and students in the Javanese language context might lessen its effectiveness. Moreover, implementing TPACK and technology integration in the online Javanese language classroom presents additional challenges. It is only feasible for some teachers to deliver lessons with technology integration effectively. Therefore, this limitation underscores the need for further research to develop teaching methods prioritizing more direct interaction between teachers and students, ultimately improving the online Javanese language learning experience. Continuous training for teachers in schools is necessary to optimize the use of technology and promote more effective online interaction. This study is also recommended for further examination to assist Javanese language teachers in schools with the structured utilization of TPACK alternatives. Consequently, developing alternative approaches to teaching within the Independent Curriculum is highly recommended.

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AN EVALUATION OF THE MANAGERIAL CONTEXT FOR DIGITAL TRANSFORMATION IN THE CONTEXT OF OPEN EDUCATION IN HIGHER EDUCATION

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ABSTRACT

This article examines the effects of technology in the field of education and management and focuses especially on the effects of technologies used in distance education activities on transformation processes. Based on research conducted, the article explains how technological developments affect education and management processes, according to the findings obtained as a result of the interviews. The technologies used in the digitalization processes of higher education institutions that provide distance education services and the effects of these technologies on the transformation processes were examined. How artificial intelligence, blockchain, metaverse, brain-computer interfaces and similar technologies can be used in education and organizational management processes and how this use affects management processes are discussed. Findings show that technological developments have profound effects on the processes in educational environments and transform management processes. As a result, the research emphasizes the need for further research and application to effectively use technologies such as artificial intelligence, blockchain, and metaverse in education and management processes. It is stated that advances in this field can cause significant transformations in education and management.

Keywords: Open and distance education, higher education, management of education, digital transformation.

INTRODUCTION

Developments in technology lead to changes in many areas that affect people in daily life. Education is one of the areas affected by this change, which occurs in a wide range from health to commerce, from citizenship applications to smart cities. In the 21st century, distance education activities, which are carried out with the mission of providing equality of opportunity in education, especially in higher education institutions, and providing learners with the opportunity to learn independent of time and space, stand out as the services that benefit from technology at the highest level and therefore are most affected by technological developments. Looking at the literature, it is possible to find different studies on the digital transformation processes of higher education institutions.

Open and distance learning services, which offer opportunities for individuals to access information and develop themselves in their field of interest, are constantly updated with the developments in information and communication technologies and reach their stakeholders. The rapid digital transformation with the technologies used in different processes in universities has also affected distance education services. Unlike the formal system, technologies that are used in different dimensions from registration to graduation and beyond for the learner in distance education, from the opening of the program to the content of the program for the instructors in the system, from interaction to measurement and evaluation, ensure that management processes are carried out effectively and efficiently.

Today, there are developments especially in communication and information processing technology. These developments have some effects on organizations. The most important aspect of an organization is the work it aims to accomplish and the technology it uses to do this work (Kocel, 2007, p.207). What kind of work will be done, the qualifications of the people who will do these jobs, ensuring job satisfaction, the quantity and quality of production, individual or group work are all affected by the technology used (Kocel, 2007, p. 207). Technology affects individuals, groups, organizational relations and management techniques in the organization.

In their study, Tonus and Pasaoglu (2013) expressed the importance of human resources and quality in higher education, and Maral (2022) revealed the views on the perceived quality of open education in higher education by learners and instructors, and determined the aspects that need to be developed in the open education system, quality standards and the advantages of accreditation in open education according to the views of the participants.

The technology used by organizations/institutions will affect the functioning of many processes within the enterprise. The main studies expressing different views and examining the relationship between technology and organizational structure are Woodward, who tests the traditional management approach; Aston, who investigates the basic dimensions of organizational structure; Perrow, who investigates how technology can be used in management by moving from a narrow perspective to a more general perspective; Thompson, who groups the technologies used by organizations; and Tavistock Institute, which examines technology, which is an independent environmental variable, and the structure of the organization/institution, which is a dependent variable (Kocel, 2007, pp. 208-214). In the Open Education System, there are both routine and non-routine jobs, so these jobs shape the structure of the organization. When this information and the researches discussed are examined, Perrow's studies are taken as the theoretical basis for this research, since Perrow's research explains the relationship between organization and technology in the digital transformation process in the context of Open Education.

It is possible to come across different studies in the literature on the management processes of distance education and the technologies used. Kaputa et al. (2022) revealed that distance education processes in higher education institutions with digitalization are effective in accessing information and reaching the masses, as well as reducing costs related to education, Tasci and Taslibeyaz (2021) examined the studies on the digital transformation of higher education institutions, Ugur and Kurubacak (2020, 2021) evaluated the technologies employed in different processes of open and distance learning services in their studies on technological singularity and management processes of open universities. At this point, the importance of administrative processes for open education and distance education services emerges.

In this research, it is aimed to evaluate the technologies used in the digitalization processes of higher education institutions offering distance education services and the changes that these technologies will create in the managerial context, to determine the predictions for the future and to draw a road map for these transformation processes with the data obtained.

ADVANCED TECHNOLOGIES IN OPEN AND DISTANCE EDUCATION

With the advances in technology, technologies that have found a place in every aspect of life in the 21st century can also be utilized at every stage of distance education activity. With the process that started with the introduction of computers into daily life, local or global computer networks have become the main source of accumulation, access and distribution of information and communication. Institutions increase their productivity by integrating

information technology tools into their organizations and modernize themselves through processes called digitalization. One of the critical technologies of the digitalization process is artificial intelligence. Unlike the systems used before it, artificial intelligence does not only produce statistical data, artificial intelligence systems can also produce information. By imitating human intelligence, artificial intelligence aims to provide computers with a decision-making and choice-making strategy similar to human learning.

The term 'artificial intelligence' was first used at a conference held at Dartmouth College in 1956 and was basically developed with the idea that computers or robots could think (Lewis, 2014). Artificial intelligence is defined as technologies that can fulfill the qualities that are accepted as specific to humans, such as finding solutions, making sense, understanding, analyzing, generalizing and learning from past experiences (Nabiyev, 2012). With artificial intelligence, software and hardware are developed to realize certain types of human mental activities. "Productive artificial intelligence", which can produce the desired result by imitating human beings, can be considered as the initial mode of artificial intelligence at the level of imitating human beings, which is called artificial general intelligence. The version of artificial intelligence that will surpass human intelligence is called artificial superintelligence in the literature and is shown as the development that will initiate technological singularity (Ugur, 2019).

In the current age of technology, wearable technologies, which manifest themselves in many areas from shopping to health, education to media, which are daily life routines, are in constant development. Working with technologies such as sensors, receptors and artificial intelligence, wearable technologies are developed and put into use as many different technological tools from smart watches to smart wristbands, virtual reality glasses to exoskeletons. Zuckerberg used the description of an embodied internet for the metaverse, which is carried further with existing technologies and is predicted to become widespread in the near future, where the opportunity to experience the real world and the virtual world together will be offered. In the near future, new universes will be created by using technologies such as 5G, artificial intelligence and blockchain together with the Metaverse.

Brain - Computer Interfaces have an important place in this process. These interfaces are defined as technology that can collect, interpret or modify information produced by any part of the human nervous system (Wolpaw et al., 2000; Ugur, 2021). A review of different literature on inter-brain connectivity and brain-computer interfaces reveals that they have been used to transfer learned tasks from brain to brain between two rodents and to implant false memories in an animal's mind (Gil, 2020 as cited in Ugur, 2021). The Neuralink project, which can be considered in this context, was developed especially for individuals with physical disabilities or diseases such as spinal cord paralysis to gain control of their bodies (Musk, 2019).

The 21st century blockchain, which can be considered among the advanced technologies of the 21st century, can be defined as a distributed database system that enables the transfer of assets that can carry value between participants on computer/internet networks (Yildirim, 2018). In the literature, the technology has been used in the ECTS credit transfer system (Turkanovic, Holbl, Kosic, Hericko, & Kamisalic, 2018), the use of Ethereum's smart contracts to document records of acquired certificates, i.e. micro-credentials (Jirgensons & Kapenieks, 2018), its use in the management of educational processes (Bhaskar, Tiwari, & Joshi, 2020), and the integration of Internet of Things, artificial intelligence, virtual reality and augmented reality applications into open and distance learning (Sharma, Yildirim, & Kurubacak, 2020) (Ugur, 2021).

ADVANCED TECHNOLOGIES IN MANAGEMENT

When the literature is examined, it is possible to come across studies on how technological developments in the field of management affect management processes. In Appah and Oyeyemi (2018), Redmann and Kotrlik (2008) defined technology as the use of machines and techniques to solve a problem, develop a pre-existing solution to a problem, achieve a goal, address an applied input or output relationship, or perform a specific function. Technology is a resource that helps human beings to progress in their daily or business life. Technology has always been a part of the teaching and learning environment. It has become one of the resources used by instructors to facilitate student learning. Technology has changed significantly over the years and its increasing variety and accessibility has expanded the opportunities that tutorials have. Baba, Ameh, and Ezeahurukwe (2018) stated that technology has the potential to revolutionize the traditional teaching and learning process. Technology has removed the barriers of time and space to education and significantly facilitated access to lifelong learning.

According to Okoli (2010), Business Education is an important part of general education that emphasizes the acquisition of skills and competencies for use in offices and business- related occupations. For Business Education to remain relevant in meeting the needs of individuals and society, it must embrace current trends (new technologies) in the academic and economic demands of society. For Business Education to serve its purpose of meeting the needs of students and society, it is important to ensure that the quality of the education provided is in line with societal demands. Business Education needs to have curricula, tools and equipment that are able to adapt to changes associated with innovations in technologies, especially those used in modern offices and schools. It is impossible to achieve success in Business Education without the use of new technologies in the education of students. Therefore, the adaptation of new technologies to education in Business Education will help students to transfer skills and make it easier for students to find a job in an ever-changing business environment.

Artificial intelligence, blockchain and metaverse are the latest technologies recently used in businesses. Although artificial intelligence has only recently started to take place in educational institutions, there are institutions that use metaverse and provide education with this virtual reality. Especially for teaching the practices of service businesses, metaverse applications are gradually increasing in the education of institutions (Haber & Carmeli, 2019).

The use of technology in Business Education requires the application of the scientific method in solving problems related to upskilling students to meet the changing needs and demands of society. New technologies in Business Education are a tool designed to prepare students for various careers in high-tech offices. Day by day, different technologies are being used and adapted to educational institutions.

METHOD

This study is modeled as a case study, one of the qualitative research methods. The research strategy of case study is used in many situations to contribute to our knowledge about individual, group, organizational, social, political and events. Case studies are a frequently used research method in the fields of social sciences and humanities (Gilgun, 1994; cited in Yin, 2003: 1) and in the planning of social structures (Ghauri & GrOnhang, 2002; cited in Yin, 2003: 1). In case studies, instead of reaching generalization by making inferences, the emphasis is on the design to study what is most accurately understood from the situation (Denzin & Lincoln, 1985: 435). In case studies, there are stages such as collecting information, organizing the information obtained and reaching research findings through interpretation (Merriam, 1988; cited in Vural & Cenksever, 2005).

In this study, the researchers created data variations by interviewing experts on formal and informal distance education processes. The researchers of this study are academicians who have worked for more than 20 years in a higher education institution that has been providing distance education services for more than 40 years. For this study, data were collected through semi-structured interviews with academics who have at least 20 years of experience in the field of open and distance education and at least 10 years of experience in the field of distance education management, and a systematic study was carried out to ensure internal and external validity and reliability. Researcher triangulation was used for the validity of the study. Each of the researchers has expertise in more than one method and in order to ensure the validity of the research, the data obtained in the research were analyzed by each researcher and the findings were transferred to the research without biases.

Within the scope of the research, answers were sought to the following questions;

Advanced technologies (Blockchain, Augmented Reality/Virtual Reality/Metaverse, Artificial intelligence and its derivatives, Brain chips, etc.) in the future of universities offering distance education services;

1. What kind of changes in which stages of management?
2. How does it affect the structuring of organizations?
3. What impact will it have on practice/services?

It is foreseen that the results obtained from the research will be a reference for a larger-scale research project to be continued. In this context, the research participants were academics who are actively working at

Anadolu University and who have taken part in different processes from implementation to management in the field of distance education within the scope of research objectives. Among these academics, the opinions of 4 academics with at least 20 years of experience in the field of open and distance education were taken. Each of these academics are experts who have actually worked in the fields of distance education practices, technologies used in distance education processes and distance education management and have practical experience.

Their responses to the questions posed to the participants were recorded word by word and translated into English, and transcripts consisting of a total of 2442 words were created. The translation was checked by experts in both languages. Content analysis technique was used to analyze the open-ended questions in the interview, following the principles established by Braun and Clarke (2006) and George (1959) (Table 1). The data were analyzed with Nvivo 1.7.1 and a list of themes, categories and codes was created.

Table 1. Data Analysis Flowchart

Phase 1:	Familiarity with data
Phase 2:	Independent creation of the first coding
Phase 3:	Sorting codes independently according to categories and themes
Phase 4:	Meeting to compare categories and themes and to check inter-coder reliability
Phase 5:	Revising and finalizing categories and themes
Phase 6:	Frequency counting

RESULTS AND INTERPRETATION

The interpretation of the data obtained in the research is given in this section.

When the answers of the participants to the question "In the future of universities providing distance education services, advanced technologies (Blockchain, Augmented Reality/Virtual Reality/Metaverse, Artificial intelligence and its derivatives, Brain chips, etc.); what kind of changes in which stages of management?" are examined; it is seen that the participants stated that advanced technologies will have a great impact on future educational environments. The answers also emphasize that organizations need to adapt to these technologies and reorganize their processes. In the responses to this question, keywords such as technological transformation and adaptation, artificial intelligence, human factor, metaverse and virtual reality stand out.

When the response of Expert 1 is analyzed, it is seen that each of the advanced technologies has different benefits, but the use of these advanced technologies will require important decision processes and proper planning.

> *"Each of these technologies has different uses and offers different possibilities. They make our lives easier and offer opportunities to do our work in a more systematic way, faster and safer."*
>
> *"The introduction of these technologies within the organization requires important decision processes. It may require large investments at the beginning, so it is necessary to plan by accurately determining how and at which stage of the business processes they will be put to use."*

Expert 1 states that enterprises' investments in advanced technology may have high costs at the initial stage, but over time, these investments can save money in the process.

> *"Although it may initially create great costs, it will turn the investment into a positive return with the savings it will provide to the organization in terms of both financial and labor force with the opportunities it will offer over time."*

"If you have a small business, you should be cautious about making big investments in advanced technologies if they are not going to save you money."

Expert 1 warns about advanced technologies and emphasizes the importance of training artificial intelligence by feeding it with up-to-date information.

"There is a very important issue, training artificial intelligence. The current algorithm of artificial intelligence works in the form of machine learning. In other words, it tells you what you teach it. Unlike the logical artificial intelligence logic, we are used to, the current system works in this way. Therefore, the more accurate information you upload, the better/quality/accurate responses the artificial intelligence will give, close to the support service that a human would give. In this respect, it is necessary to make an effort and labor for the education of artificial intelligence. And it needs to be constantly fed with accurate/up-to-date information."

Expert 1 also expressed concern about people's existing sense of mistrust towards unmanned technologies.

"Our people want to get confirmation from a real person. No matter how much we provide information and explanations in writing or visually, they always want to confirm it from a real person."

"There is a point that leads people to distrust, even if they read it, they want to confirm it.

How the operation of unmanned systems affects this situation needs to be seen in practice."

When the answers given by Expert 2 to this question are analyzed, it is seen that he predicts that artificial intelligence will take place in managerial positions in the future.

"In the future, artificial intelligence will take place at all levels of businesses (top, middle and lower level managers). In all kinds of businesses in service, production, marketing "

Expert 2 recommends the use of augmented reality in departments that require practice or internship and states that this will soon become widespread in all distance education universities.

"Augmented reality should be used especially in departments that require practice or internships. This application will soon be available at all universities offering distance education services."

Expert 2 emphasizes that the centralization provided by the blockchain will provide better control.

"As for blockchain, it is a very important application for centralized management. With centralization, control will be better, which will cause things to be done properly and completely."

Expert 2 states that businesses will move from a hierarchical to a horizontal structure, network organizations will increase and lists the benefits of this change.

"It shapes businesses from a hierarchical to a horizontal structure. There will be a single manager, no class differences between people, work and communication will be faster, and creativity will increase."

"Network organizations will also increase. Businesses will buy an application that they can do themselves at a higher cost from other businesses that do it better and will cost less when purchased."

Expert 2 also mentions the issue of employment in his answers. According to Expert 2, instead of employees who cannot adapt to advanced technologies, employees who use advanced technologies and produce knowledge are permanent.

"Employees who are not open to technology or cannot use it will be eliminated and replaced by people who produce knowledge and use technology. Since there will be people with high creativity and risk-takers, difficulties in implementation will be easily overcome. There will be no loss of time and spatial difficulties."

In his answers to this question, Expert 3 states that customized learning experiences can be offered to students with the support of artificial intelligence and mentions his expectations about this.

"Options such as the end-to-end production of distance education content with fully synthetic content, the introduction of new reality-based distance education and support services, and the provision of AI-powered personal teaching assistants to students will become cheaper."

"Creating student-specific curricula and content can be realized at almost zero cost."

"It will be possible to design a customized learning experience every time a student logs in. Students' learning analytics and their real-time analysis with artificial intelligence will support administrative processes."

"Brain-computer interfaces can enable each student to have an adaptive learning experience that best suits their current mental state."

Expert 3 predicts that the effective use of advanced technologies in management processes

can be of great support to management.

"Meanwhile, functions such as management, planning, supervision and evaluation will all become more efficient with the support of AI."

"Intensive use of these technologies will, with appropriate design, lead to a reduction in the management hierarchy."

"Artificial intelligence, especially when used effectively in anomaly detection, can provide great support to the management in early identification and prevention of unexpected situations in service delivery and teaching processes."

"It will cause restructuring in processes such as book writing, e-learning content preparation, live course presentation, etc."

"Processes such as preparing exam questions and evaluating open-ended exams can be handed over to artificial intelligence."

"Points that require human use, such as offices, will be eliminated."

Finally, Expert 3 talks about the new situations that students will experience in universities where advanced technologies are used intensively and what universities can do for these situations.

"Students will face more artificial intelligence, synthetic content and hyper-realistic avatars in their learning, assessment and support. As these technologies, when applied globally, will lead to similar, taken-for-granted services and environments, universities will want to differentiate themselves by incorporating creative designs that allow students to come face-to-face with humans from time to time."

"Open course materials that incorporate advanced technologies will also become widespread, reducing students' dependence on institutions for content delivery."

"Universities can be expected to reposition themselves and perhaps focus only on assessment and evaluation processes."

In his answers to this question, Expert 4 mentions the use of augmented reality, artificial intelligence and metaverse worlds in education.

"Existing technologies and systems where next-generation technologies can be put into use as quickly as possible are available at every stage of distance education."

"With virtual and augmented reality, the need for education and training environments to take place in the metaverse worlds of the future is inevitable."

Expert 4 states that advanced technologies will be effective at every stage of a distance learning program, including taking over the guiding role of the instructor.

"In the learning environment, an AI-powered meta-assistant can take over the guidance role of the actual instructor, provide access to content at the right time and in a meta- environment, and evaluate what and how much the individual accessing the content has learned."

"These technologies can bring about radical changes at every stage of a distance education program, from opening to delivery, graduation, social activities, interaction and assessment."

"This service can change by transferring the role of an academic lecturing in the system to an artificial intelligence-supported assistant application, internship processes can be realized with simulation software that will determine how the knowledge to be acquired will be used in which situations, or practical course content can turn into processes that individuals will experience with their virtual selves in the metaverse."

Expert 4 continues his predictions by listing what can be done with a chip implanted in the student's brain.

> *"It can use blockchain technologies to recognize prior learning, and it can be with the individual anytime, anywhere through the chip implanted in their brain."*
>
> *"Backups of the traces in the brain of the individual's knowledge and experiences related to the subjects they have learned can be taken, stored digitally, and transferred between brains or between brain and computer."*
>
> *"Evaluations on how much knowledge and experience individuals have on which subject or how much knowledge they have acquired can be taken to a new dimension with the combination of blockchain and metaverse technologies, and even the learning content and information offered can be transferred directly to brain chips."*

Expert 4 emphasizes that processes will be carried out with advanced technologies, which will lead to a reduction in human resources, but employment will still be needed.

> *"Processes can be coordinated and managed by artificial super intelligence systems." "The reduction in human resources will lead to a more digital hierarchical structure."*
>
> *"All processes will be driven by technology, but of course it is appropriate that the people who manage these technologies remain human."*

Finally, Expert 4 draws attention to the need for higher education institutions to take steps in the process of transition to advanced technologies.

> *"Artificial intelligence-supported systems will play a more active role in the management and organization of all these new processes of the higher education institution."*
>
> *"Services themselves and their implementation processes as well as their production processes will undergo radical change. At this point, organizations need to take steps as soon as possible to prepare themselves for this future."*

When the answers given to this question are evaluated in general, it is seen that the participants especially emphasized that artificial intelligence and advanced technologies should be included in the processes today. When the literature is examined, it is seen that many studies have been conducted on the use of artificial intelligence and advanced technologies in different processes of distance education, from management to practice. In addition, with the introduction of productive artificial intelligence, it is clear that there is a need for a rapid transformation in distance education processes, considering its effects on business processes and human resource utilization in different fields. In their studies, Ugur and Kurubacak (2019a, 2019b, 2020) developed recommendations on how to employ and manage artificial intelligence and advanced technologies for all processes of distance education, while Durso and Arruda (2022), in their content analysis of research on the use of artificial intelligence in distance education in Brazil, found that limited attention was paid to critical issues related to the increasing inclusion of artificial intelligence in distance education, such as the employability and technological training of teachers or the ethical implications of using artificial intelligence for the educational process. The needs identified in this study overlap with the results of the related study, so it can be said that there is a need for studies on the inclusion of artificial intelligence in distance education processes and the training of instructors on this issue.

The second question asked to the participants was "Do these advanced technologies affect the economy and how?".

When the answers given to this question are analyzed, the view that businesses should determine the right strategies and plan the integration of advanced technology in a balanced way with investments in human resources comes to the fore. Investment in Technology and Integration, Unemployment and Productivity, Artificial Intelligence and Automation and Block Chain, Artificial Intelligence and Human Resources are the prominent themes. When the responses are analyzed on a participant basis, it is seen that Expert 1 emphasized that investments in technologies should be large investments at the beginning, but that the right analysis should be made before technology integration.

> *"Initially, you need to invest heavily in the configuration of technologies. If it will really benefit you in terms of reducing costs, employing fewer people, spending less time of the qualified workforce, then you should turn to these technologies. Analyses must be done correctly before technology integration."*

In his answer to this question, Expert 1 warns that businesses that try to implement the use of advanced technology without proper analysis simply because it is fashionable will lose labor and money.

> *"If we try to integrate these technologies thinking that we should have them because they are fashionable, our business processes will be difficult, we will spend a lot of effort on the path we will take in one step, and our money will be wasted."*

In his response to this question, Expert 2 underlines that advanced technologies may increase unemployment and that especially those who are not technologically literate may be affected. Expert 2 included the following statements in his answer:

> *"It will affect the economy because a lot of people will be unemployed. Especially people who can't keep up, who can't produce knowledge or use technology."*

However, Expert 2 emphasizes that with the use of advanced technologies, the production of enterprises will increase and they will gain profit over time.

> *"Businesses will make a profit because they will not use as many human resources, money will flow more because production will increase and error rates will decrease. As different products will be produced, the country's exports will increase."*

According to Expert 3, what stands out is that entry-level white-collar jobs will disappear with artificial intelligence that will be able to make key decisions.

> *"In a world where basic everyday decisions are made by AI, millions of entry-level white- collar jobs will disappear."*

Expert 3 predicts that businesses will prefer to manage more AI processes with fewer employees and that a global wave of automation can be expected.

> *"One view is that AI will increase human productivity. But rather than employing large numbers of AI-enhanced workers, businesses will invest in automation, preferring processes in which a small number of workers oversee a large number of AI endpoints. We can expect a new wave of automation with cheap robots in every field globally."*

In his response to this question, Expert 4 states that technologies such as blockchain, artificial intelligence and metaverse will lead to radical changes in the economic sense.

> *"Advanced technologies, especially Blockchain, artificial intelligence, metaverse technologies, will bring radical changes in the economic sense."*

Expert 4 emphasizes that while advanced technologies can save human resources and time, they can also lead to new costs.

> *"It can save human resources and time, but will also open the door to new costs by investing in the infrastructure required for the technologies."*

Expert 4 also states that new human resources will be needed to manage advanced technologies and new employment opportunities will be created.

> *"New human resources will be needed to manage technologies that seem to have the potential to do many human-based jobs, and new business areas will open up."*
>
> *"It is important to make accurate cost-benefit calculations for automation systems supported by artificial general intelligences that can undertake human-assisted work."*
>
> *"There is also a need to invest in human resources to manage technology."*

The responses to this question point to the possibility of artificial intelligence and robotic technology replacing labor on an unprecedented scale, which raises the concern of automation (Autor, 2015: 4). The advancement of technology and the use of technology to do the work of human resources still helps the economy in terms of employment. The use of technology has led to increased productivity in production, increased exports and imports, and increased demand for goods and services. On the one hand, the disruption effect, which requires the reorganization of labor supply as technology replaces labor; on the other hand, the emergence of new jobs in sectors with high productivity is met by the increase in employment in these sectors (Frey & Osborne, 2013:13). Both positive and negative ideas about AI are included in the economic element. The

positive idea predicts that artificial intelligence will bring qualified people into business life. The negative idea predicts that artificial intelligence will have hidden unemployment by replacing employees. Because using artificial intelligence means less labor input (Huang et al., 2019: 45). A joint study by Nesta, a London-based innovation group, and Oxford University academics ranked the job groups in the US that would be least affected by computerization. According to the research;

a. Translators and interpreters (5.8%) b. Performing artists (7%) c. Radio broadcasters (7.7%) d. Film and TV producers (8%) e. R&D in natural sciences (10.9%) In addition, the job groups most vulnerable to computerization are: a. Office managers b. Call center workers c. Librarians d. Cattle breeders e. Wood cutters f. Miners g. Car dealers and hotel staff (Dirican, 2015:569).

Stiglitz (2014) argued that unemployment will increase due to increased productivity and innovations in human resources managers. Artificial Intelligence is becoming even more important in the economy. Research by PricewaterhouseCoopers (PwC) reveals that Artificial Intelligence will increase in importance in the global economy by 2030. Accordingly, Artificial Intelligence is expected to increase global GDP by approximately 14 percent. It is thought that a total increase of approximately USD 15.7 trillion will be achieved. Another study, launched by Accenture in 2016 and covering 12 developed economies, estimates that Artificial Intelligence could double annual global economic growth rates by 2035 (Business, 2023).

Finally, the participants were asked the question "Do these advanced technologies create socio-cultural change, and if so, in what form?". According to the answers given to this question, it is possible to talk about the effects of advanced technologies on socio-cultural change. On the other hand, the dilemma experienced by experts regarding these effects is observed. The importance of the factors that need to be taken into account in order to cope with this change and the balance that needs to be established between the opportunities and risks brought by advanced technology come to the fore.

According to Expert 1, advanced technologies affect individuals' lives in a wide range of areas, from their daily lives to their professional lives. Emphasizing that the developments related to artificial intelligence are rapid, he drew attention to the positive effects as well as the negative effects such as laziness.

> *"Recent developments in the field of artificial intelligence are progressing at a dizzying pace."*
>
> *"Sometimes it makes things easier, sometimes it makes us lazier and easier."*
>
> *"It will definitely have negative effects such as making people a little more ready-made, making them dependent on themselves, increasing their screen usage time."*

Expert 1 also gives a number of examples of the use of AI.

> *"Today you can have a piece of writing edited, revised in the tone you want (friendly, formal), changed to the style of a writer you like, etc. etc."*
>
> *"Let's say you don't have an opinion on a topic; you can ask "if you were that person, how would you answer this?" and get an answer."*
>
> *"Let's say you have no drawing skills at all; you can have them draw an image by explaining it to them by saying "now draw me a ladybug, surrounded by..."*

Finally, Expert 1 emphasizes that the positive use of these technologies can be ensured through technology literacy trainings.

> *"The society should be taught how to use these technologies in a positive way through technology literacy trainings."*

When the responses of Expert 2 are analyzed, it is seen that he draws a more negative picture. It is emphasized that the country is not yet ready for artificial intelligence technology due to its collectivist and feminine culture.

> *"Our country is not yet ready for AI technology. Because we have a collectivist and feminine culture, we are not yet ready for rational and rule-following applications of AI."*

On the other hand, Expert 2 states that he predicts that artificial intelligence will lead to a great change for humans with the disruptive effect it will bring.

> *"It will have a disruptive effect. People's thinking, communication and lifestyles will be 180 degrees different from what is happening now."*

Expert 3 states that advanced technologies have more power than social media to change the world.

> *"Given the extent to which social media has changed the entire world in the last two decades, we can predict that synthetic reality, artificial intelligence and brain-computer interfaces could trigger even more of this change."*

Expert 3, who mentions psychological and biological problems in his answers, also draws attention to virtual addiction.

> *"It is very clear that virtual/augmented/enhanced reality in particular will add a layer between individuals and the outside world, and this layer will further distance individuals from physical communication. People spending more and more time in the virtual world will cause permanent problems in human psychological and biological functions. Advanced virtual addiction will disrupt the fulfillment of the requirements of the physical world. A major social problem awaits us in the future."*

In his response to this question, Expert 4 emphasizes the concepts of "Cyber Culture" and "Meta Culture" while stating that technology has already changed social life and cultural structure. He states that individuals living in meta-universes, especially those born into technology, can exist both in the physical and virtual world and that this situation should shape the cultural structure.

> *"When this situation is evaluated in the context of the construction of a future in which there are individuals born into technology, it can be predicted that this new culture living in meta-universes, let's call it meta-culture, will be formed. Meta-culture will refer to human beings and these human communities that exist both in the physical world and in the virtual world."*

Expert 4 emphasizes the need to start working on how to address issues such as rights, legal regulations and ethics in meta-culture.

> *"In this case, it is clear that there will be a need for studies on what will be the determinants of rights in these universes, what kind of legal and ethical regulations will be applied for who or what, and how the cultural structure will be shaped in these meta- societies, and research on these issues should be started now."*

Looking at the effects of artificial intelligence on society, it is evaluated that the main determinant of whether artificial intelligence has a negative or positive function is the human being who constructs it (oztemel, 2020:99). In fact, it is not taken into consideration that advanced technologies are created by humans. Therefore, it is ignored that the human element, especially people with creative and advanced ideas, are more important than advanced technology and that they should be valued. There is a change in society with the use of advanced technology. In particular, while emphasizing the positive aspects of artificial intelligence that facilitate life, on the other hand, there are also ideas about the lack of control or the emergence of negative effects (O'Connell, 2021: 87; Gultekin, 2021: 132). Today, it seems possible that artificial intelligence can be a project that can be a guiding field of development and change in the reconstruction of societies, as well as a project that can create difficulties with its consequences (Baudrillard, 2018: 113). However, according to Koroglu (2017), these concerns are unwarranted as they are determined by what and how, which are the questions involved in the structuring of artificial intelligence, and it is not possible for it to leave human control without modeling "why".

Artificial intelligence applications, which are evaluated with the acceptance of a political functionality, are almost imposed in a wide range of social life, who will hear, see, acquire, give up, like or dislike what, provide social guidance, and prepare the ground for social changes in this direction (Beer, 2017:6). With the impositions imposed by artificial intelligence, it is emphasized that individuals are almost exploited, and an economic, social and cultural imperialism corresponds as an application area (Muhloff, 2020: 1882). Social change is shaped by who, when, where and how artificial intelligence applications target (Joyce et al., 2021:6). Artificial intelligence, as a social actor in today's world, causes changes in society (Woolgar, 1985:558).

The themes-categories and codes formed from the data obtained by analyzing all responses are given in Table 2.

Table 2. Themes, Categories, Codes and Example Phrases

Themes	Categories	Codes	Example Phrases
Education	Technology	Investment Cost	Although it may create great costs at the beginning, it will turn the investment into a positive return with the savings it will provide to the organization in terms of both financial and labor force with the opportunities it will offer over time.
		Education of Artificial Intelligence	There is a very important issue, training artificial intelligence. The current algorithm of artificial intelligence works in the form of machine learning. That is, it tells you what you teach it. Unlike the logical artificial intelligence logic we are used to, the current system works in this way. Therefore, the more accurate information you upload, the better/quality/accurate responses the artificial intelligence will give, close to the support service that a human would give. In this respect, it is necessary to make an effort and labor for the education of artificial intelligence. And it needs to be constantly fed with accurate/up-to-date information.
		Changing Educational Environments	With virtual and augmented reality, the need for education and training environments to take place in the metaverse worlds of the future is inevitable.
		Brain Chips	Evaluations on how much knowledge and experience individuals have on which subject or how much knowledge they have acquired can be taken to a new dimension with the combination of blockchain and metaverse technologies, and even the learning content and information offered can be transferred directly to brain chips.
	Educational Processes	Adaptive Learning	It will be possible to design a customized learning experience every time a student logs in. Students' learning analytics and their real-time analysis with artificial intelligence will support administrative processes.
		Virtual Self	This service can change by transferring the role of an academic lecturing in the system to an artificial intelligence-supported assistant application, internship processes can be realized with simulation software that will determine how the knowledge to be acquired will be used in which situations, or practical course content can turn into processes that individuals will experience with their virtual selves in the metaverse.
		Recognition of Prior Learning	It can use blockchain technologies to recognize previous learning, and it can be with the individual anytime, anywhere through the chip implanted in their brain.
		Management	Processes can be coordinated and managed by artificial superintelligence systems.
		Implementation Processes	Services themselves and their implementation processes as well as their production processes will undergo radical change. At this point, organizations need to take steps as soon as possible to prepare themselves for this future.
	Services	Meta Assistant	In the learning environment, an AI-powered meta assistant can take over the guidance role of the actual instructor, provide access to content at the right time and in a meta-environment, and evaluate what and how much the individual accessing the content has learned.
	Content	Adaptive Content Production	Creating student-specific curricula and content can be realized at almost zero cost.
		Independence from the Organization	Open course materials that incorporate advanced technologies will also become widespread, reducing students' dependence on institutions for content delivery.
Management	Management	Decision processes	The introduction of these technologies within the organization requires important decision processes. Initially it may require large investments, so it is necessary to plan by accurately determining how and at which stage of the business processes it will be put to work.

	Planning, supervision and evaluation	Meanwhile, functions such as management, planning, supervision and evaluation will all become more efficient with the support of AI.
	Hierarchy reduction	Intensive use of these technologies will lead to a reduction in the management hierarchy with appropriate design.
	Artificial intelligence manager	In the future, artificial intelligence will take place at all levels of businesses (top, middle and lower level managers). In all kinds of businesses in service, production, marketing.
	Structure	It shapes businesses from a hierarchical to a horizontal structure. There will be a single manager, no class differences between people, work and communication will be faster, and creativity will increase.
		Network organizations will also increase. Businesses will buy an application that they can do themselves at a higher cost from other businesses that do it better and will cost less when purchased.
Employment	Knowledge worker	Employees who are not open to technology or cannot use it will be eliminated and replaced by people who produce knowledge and use technology. Since there will be people with high creativity and risk-takers, difficulties in implementation will be easily overcome. There will be no loss of time and spatial difficulties.
	Automation anxiety	One view argues that AI will increase human productivity. But rather than employing large numbers of AI-enhanced workers, businesses are more likely to invest in automation, with a small number of workers overseeing a large number of AI endpoints. We can expect a new wave of automation with cheap robots in every field globally.
	Employment growth	New human resources will be needed to manage technologies that seem to have the potential to do many human-based jobs, and new business areas will open up.
	New business areas	New human resources will be needed to manage technologies that seem to have the potential to do many human-based jobs, and new business areas will open up.
	White collar reduction	In a world where basic everyday decisions are made by AI, millions of entry-level white- collar jobs will disappear.
Economy	Cost increase	It is important to make accurate cost-benefit calculations for automation systems supported by artificial general intelligences that can undertake human-assisted work.
	Hidden unemployment	It will affect the economy because a lot of people will be unemployed. Especially people who can't keep up, who can't produce knowledge or use technology.
	Investment	Initially, you need to invest heavily in the configuration of technologies. If it will really benefit you in terms of reducing costs, employing fewer people, spending less time of the qualified labor force, you should turn to these technologies. Analyses must be done correctly before technology integration.
	Becoming fashionable	If we try to integrate these technologies thinking that we should have them because they are fashionable, our business processes will be difficult, we will spend a lot of effort on the path we will take in one step, and our money will be wasted.
	Profit increase	Businesses will make a profit because they will not use so many human resources, money will flow more because production will increase and error rates will decrease. As different products will be produced, the country's exports will increase.
Sociocultural Impact	Increased laziness	Sometimes it makes things easier, sometimes it makes us lazier and easier.
		It will definitely have negative effects such as making people a little more ready-made, making them dependent on themselves, increasing their screen usage time.
	Lifestyle change	"It will have a disruptive effect. People's thinking, communication and lifestyles will be 180 degrees different from what is happening now."

	Psychological-Sociological problems	In particular, it is clear that virtual/augmented/enhanced reality will add a layer between individuals and the outside world, and this layer will further distance individuals from physical communication. As people spend more and more time in the virtual world, it will cause permanent problems in human psychological and biological functions. Advanced virtual addiction will disrupt the fulfillment of the requirements of the physical world. A major social problem awaits us in the future.
	Collectivism and femininity culture	Our country is not yet ready for AI technology. Because we have a collectivist and feminine culture, we are not yet ready for the rational and rule-following applications of artificial intelligence.
	Meta culture	When this situation is evaluated in the context of the construction of a future in which there are individuals born into technology, it can be predicted that this new culture living in meta-universes, let's call it meta-culture, will be formed. Meta-culture will refer to human beings and these human communities that exist both in the physical world and in the virtual world.
	Cultural structure	In this case, it is clear that there will be a need for studies on what will be the determinants of rights in these universes, what kind of legal and ethical regulations will be applied for who or what, and how the cultural structure will be shaped in these meta-societies, and research on these issues should be started now.
	Decreased communication	In particular, it is clear that virtual/augmented/enhanced reality will add a layer between individuals and the outside world, and this layer will further distance individuals from physical communication. As people spend more and more time in the virtual world, it will cause permanent problems in human psychological and biological functions. Advanced virtual addiction will disrupt the fulfillment of the requirements of the physical world. A major social problem awaits us in the future.

When the table is analyzed, the diagram created with the concepts, codes and categories reached in the research is given in Figure 1.

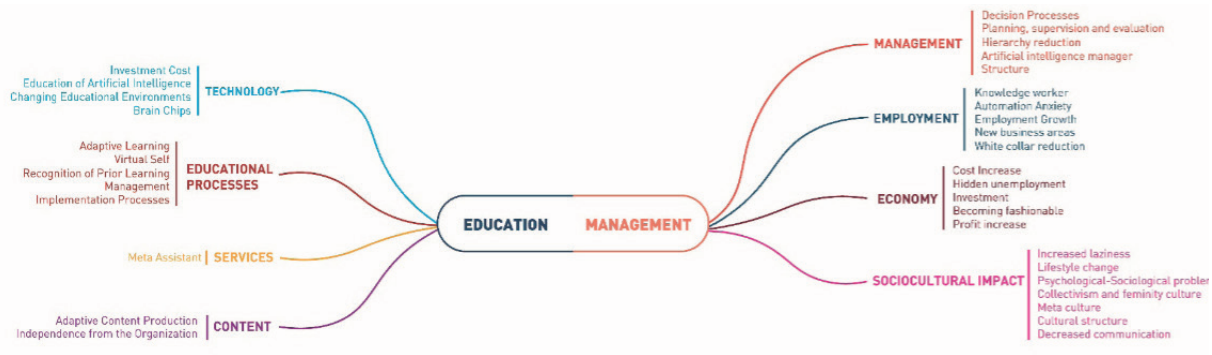

Figure 1. Concept and codes diagram

When the findings and the diagram were analyzed, it was determined that the categories that the participants drew attention to the most were technology, educational processes, services and content in the context of education, while the dimensions of management, employment, economy and socio-cultural impact in the context of management. The research codes obtained by analyzing the opinions of the participants are; investment cost, artificial intelligence education, change of educational environments, brain chips, adaptive learning, virtual self, recognition of prior learning, management, implementation processes, meta assistant, adaptive content production, independence from the institution, decision processes, planning, supervision and evaluation, hierarchy reduction, artificial intelligence manager, structure, knowledge worker,

automation anxiety, employment increase, new business areas, white collar reduction, cost increase, hidden unemployment, investment, fashion, profit increase, laziness increase, psychological-sociological problems, collectivism and femininity culture, lifestyle change, meta universe, cultural structure, communication decrease.

CONCLUSION AND RECOMMENDATIONS

In this study, the digital transformation processes that advanced technologies will affect in the field of open and distance education in an administrative context were evaluated. The prominent technologies within the scope of the research are artificial intelligence, metaverse, brain-computer interfaces, blockchain, brain chips, virtual reality technologies. The educational dimensions that will be affected by these technologies are technology, educational processes, services, content, while the managerial dimensions are identified as management, employment, economy, culture, socio-cultural change and management. The main themes of the research are education and management.

In the context of education, it is clear that the impact of technological developments on the process is inevitable. Artificial intelligence and recently popularized productive artificial intelligence applications are already experiencing a rapid transformation process. It has been observed that blockchain technologies should be employed in the processes of recognizing prior learning, creating adaptive learning opportunities, creating synthetic content with artificial intelligence, using artificial intelligence in the organization of the educational process, taking on the role of a tutor, using brain-computer interfaces in the development of learning systems, preparing new learning structures for the metaverse and structuring avatar systems for virtual self development. However, of course, calculating the investment costs and analyzing the economic impacts will be useful for the feasibility and sustainability of the process.

When evaluated in the context of management, it is clear that especially management processes and therefore managers need to undergo a rapid adaptation to this change. Artificial intelligence and blockchain technologies can be used in the processes of making managerial decisions, planning, supervising and evaluating activities, and managers to be developed with artificial intelligence will be able to take place at all levels of businesses in the future. Systems to meet the need for knowledge workers and automation concerns within the scope of employment processes can be met with technologies such as artificial intelligence, blockchain and human-computer interfaces, and contrary to the decrease in white-collar employees, there will be an increase in employment for new business areas. This need will open new business doors for people with a high level of technological literacy. Considering the economic effects, although it is seen that it will require great costs in the current conditions, in the long run, it will be able to provide financial gains due to the return of automation systems and the effect of the reduction in human resources, and the increase in production will also provide profit. With changing lifestyles, there may be an increase in laziness and psychological problems in individuals. With these changes, falling behind in terms of technological readiness will have positive and negative effects on the sociological dimension. Another impact of technology will be the emergence of virtual societies and thus the emergence of meta-culture. When cultural effects are evaluated here, it can be said that the decrease in real communication that will occur with changes in lifestyle will change the culture of collectivism.

When evaluated in the context of the sustainability of the current research, according to the results of the research, it is recommended to develop and test artificial intelligence assistants and managers, develop certification and recognition applications with blockchain technologies in management and education processes, develop and use adaptive synthetic content by using artificial intelligence technologies, configure new teaching systems and virtual selves for the metaverse, and conduct new research on the use of brain-computer interfaces and brain chips in both managerial and educational processes.

Considering the results obtained from this study, larger-scale studies using qualitative and quantitative methods can be conducted in different geographies, with academics from different universities and fields. The current research is also thought to be a basis for academics and researchers who want to conduct research in this field.

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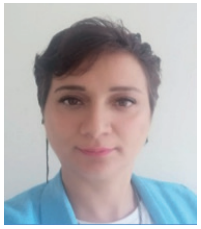

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INTERCULTURAL USABILITY IN E-LEARNING OBJECTS PREPARED FOR TEACHING TURKISH TO FOREIGNERS

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ABSTRACT

This research investigates the intercultural usability factor of e-learning products designed for the instruction of Turkish as a foreign language. The subject of study, "Ana Dil Turkce," refers to a freely accessible and distant education platform developed by Anadolu University with the purpose of instructing non-native speakers in the Turkish language. This study employed a concurrent mixed methods research design to investigate the intercultural usability of the "Ana Dil Turkce" e-learning system. The study incorporated a qualitative component through the utilization of a case study methodology, while a cross-sectional survey design was employed to address the quantitative part. The quantitative portion of the study employed descriptive methods, whereas the qualitative portion utilized content analysis methods. The qualitative component of the study involved the participation of 25 individuals who were active and registered users in the system during the period from 2020 to 2022. Additionally, the quantitative component of the study included the participation of 211 users. The quantitative portion of the study employed a questionnaire as a method of data collection, while the qualitative component utilized a semi-structured interview format. The study's conclusions were analyzed through the integration and juxtaposition of qualitative and quantitative data. The study yielded findings regarding the cultural appropriateness of the Ana Dil Turkce e-learning objects. The findings indicate that the cultural learning objects inside the e-learning system are deemed adequate, albeit requiring further development and enrichment.

Keywords: Teaching Turkish as a foreign language, intercultural usability, e-learning, e-learning objects.

INTRODUCTION

E-learning presents certain advantages that are particularly well-suited for foreign language teaching, mostly due to its technological capabilities. These capabilities facilitate autonomous learning and have the ability to significantly enhance an individual's motivation to learn (Son, 2010). According to Nokelainen (2006) and Hadjerrouit (2010), e-learning products designed for foreign/second language instruction demonstrate efficacy, user-friendliness, memorability, enjoyment, originality, and incorporate educational and cultural

components. E-learning objects encompass more than mere content that is posted and concluded within the e-learning environment. Learning objects refer to interactive tools that are accessible on the internet and are designed to facilitate the acquisition of particular concepts by enhancing, reinforcing, or directing students' cognitive processes (Kay & Knaack, 2009). According to Litteljohn (2003), McGee (2006), and Keller (2008), it is imperative for these elements to possess the qualities of customizability, adaptability, updatability, trackability, and measurability. To assess the usability of the generated material, tools, and e-learning environments, it is essential to analyze these systems from pedagogical, cultural, and technical perspectives (Jeng, 2005).

The study context of "Ana Dil Turkce" pertains to a freely accessible platform that encompasses e-learning resources specifically designed for the instruction of Turkish as a second language. The Turkish language is known as "Ana Dil Turkce" in academic discourse. The Turkish Certificate Program, initiated in 2006, was formulated as part of the "tsp.anadolu.edu.tr" initiative of Anadolu University. The system has been operational since the year 2018. The language resource "Ana Dil Turkce" encompasses content categorized into proficiency levels A1, A2, B1, B2, C1, and C2, accompanied by a user guide. Additionally, it provides assistance for English, Arabic, and Russian languages, and offers many features including multimedia content. The Turkish language e-learning environment, known as Ana Dil Turkce, encompasses various modules including user-system interaction, learning, assistance, assessment, and evaluation. The platform provided a variety of learning materials, including e-courses, video lessons, games, and audio files, to facilitate the acquisition of proverbs, idioms, grammatical rules, and phrases. These learning contents were organized thematically, allowing for a comprehensive understanding of the many linguistic elements.

The assessment of current e-learning systems within the framework of pedagogical, technological, and intercultural usability, along with the identification of relevant criteria, can facilitate the development of future e-learning settings. This research focuses on the intercultural usability dimension, which is a crucial evaluation criterion for e-learning objects, employing a user-centered approach. The objective of this study is to ascertain the cultural attributes of e-learning materials developed for the purpose of instructing Turkish as a second language. This study represents the initial and sole investigation of the "Ana Dil Turkce" e-learning system developed by Anadolu University, focusing specifically on its intercultural usability. This study included a comprehensive questionnaire that encompassed pedagogic, technical, and multicultural aspects of usability. The primary inquiry of this investigation is as follows: "What are the perspectives of learners utilizing e-learning objects in the Ana-Dil Turkce with regards to Turkish culture and cultural interaction within the framework of intercultural usability?" This setting will first explore the concepts of usability and cross-cultural usability in the realm of e-learning items.

REVIEW OF LITERATURE

Usability in E-Learning Objects

E-learning objects ought to possess attributes that render them accessible, collaborative, adaptable, reusable, durable, cost-effective, assessable, discoverable, managed, trustworthy, addable, detachable, and replaceable. E-learning systems and learning objects in their content strive to address the requirements of learners by employing a combination of cultural, technical, and pedagogical strategies to fulfill specific demands. From a pedagogical-educational perspective, the paramount characteristic of e-learning items is in their individualized nature. The inadequacy of e-learning objects from a pedagogical perspective arises due to their inconsistency in aligning with specific educational philosophies, disciplines, and approaches such as structuralism, cognitivism, and behaviorism. Furthermore, it is imperative that e-learning objects are developed in alignment with the principles of intercultural communication. In order to achieve success in the process of cultural learning, it is necessary to take into account the cultural learning objectives within each language and include information into the learning systems (Hanewald, 2009).

Longmire (2000) emphasizes the importance of considering various factors in the design of learning objects. These factors include flexibility, which allows for adaptability and customization; easy updating, ensuring that content remains current; consistent content management, promoting coherence and organization; suitability for personal learning, accommodating individual preferences and needs; interoperability between

different multimedia environments, enabling seamless integration; collaborative learning environment, fostering cooperation and interaction; accessible and understandable format, ensuring usability for all users; easy availability, facilitating widespread access; competence-based learning, emphasizing the development of specific skills and knowledge; intercultural awareness, promoting understanding and respect for diverse cultures; universal language, facilitating communication across different linguistic backgrounds; and technology use, harnessing the potential of technological tools in the learning process. However, it is worth noting that scholars conducting research in this field emphasize the significance of user-centered design concepts and the development of useful products in the context of e-learning objects (Corry et al., 1997; Dumas & Redish, 1993; Eason, 1988; Gould & Lewis, 1985; Shackel, 1991). When designing e-learning items, it is crucial to prioritize the learner and ensure that the content provided enhances their motivation to study (Zaharias, 2009, p.41). In essence, the concept of usability in learning objects pertains to the user's capacity to locate desired information or fulfill their expectations without the need for inquiries, obstacles, or reluctance.

In order for a product to be considered usable, it should possess qualities that are deemed useful, efficient, effective, rewarding, accessible, and learnable. To enhance usability, it is imperative to integrate user interface design, technical communication, and support services into the product during the process of product creation. Norman (1993) asserts that a formative e-object should possess certain characteristics. These include interactivity, the provision of feedback, the presence of specific goals, motivation, the ability to stimulate a sense of challenge, and the availability of appropriate tools. Additionally, such e-objects should not disrupt the learning process or introduce distractions. They should also align with cultural and pedagogical norms, while ensuring the maintenance of a seamless learning flow. E-learning objects have the potential to incorporate culture-based and blended learning theories, thereby including a diverse range of content such as movies, music, artistic items, and daily life aspects pertaining to the target culture. Additionally, these objects can offer insights into the worldview of individuals who speak the target language. According to Hunaiyyan et al. (2008), learning objects might be conceptualized as "cultural learning objects." Blandin, a critic of the exclusive adoption of user-centered approach in usability of e-learning objects, highlighted the significance of social aspects that influence the usability of online learning programs. Specifically, Blandin emphasized the impact of intercultural learning disparities and the concept of "learning culture" on usability. In line with scholarly discourse, it is imperative to consider usability not solely based on factors such as simplicity of use, motivation, and beauty, but also in relation to social and cultural learning behaviors. Furthermore, the examination of user experience should encompass a sociological perspective, as suggested by Blandin (2003).

The consideration of intercultural usability is a significant consideration while building e-learning materials. The prominence of pedagogical design is seen in online language learning environments. The subsequent analysis focuses on the technical interface dimension, with the aim of verifying the adaptability and user-friendliness of online language learning platforms. However, in the present day, it is insufficient to solely focus on pedagogical and technological usability while developing e-learning content. In the context of an increasingly interconnected global society, there is a growing emphasis on incorporating cultural considerations into the design of instructional approaches, particularly in relation to influencing the development of technical interface designs. The attitudes and behaviors of users in interface design are influenced by cultural factors. A correlation exists between the learning culture of learners and the design and usefulness of instructional approaches (Ogunbase, 2016).

The incorporation of user/learner-centered design has been given careful consideration, particularly in the assessment of the technological usability aspect of the Ana Dil Turkce e-learning system. The consideration of design, as a determinant of usability, is a crucial aspect within the framework of product development, specifically within the context of the individual-society-culture triangle. Venkatesh, Morris, and Davis (2003) posited that the association between performance expectation and behavioral purpose, as termed by the authors, is influenced by factors such as age, gender, experience, and culture, distinguishing their perspective from previous usability theories. Furthermore, the diverse requirements and preferences of numerous learners with varying learning styles need the ongoing development of any web-based educational platform. It is imperative for educational environments to consider the impact of institutional, legal, ethical, political, and cultural advancements on the curriculum.

In their study, Kukulska-Hulme and Shield (2004) identified the key factors that need to be taken into account when evaluating the usability of technology-assisted language learning. The focus of their research was on e-learning systems and materials designed for teaching foreign languages, with particular attention given to pedagogical design, intercultural usability, and interface evaluation. As stated by Kukulska Hulme and Shield (2007), it is imperative to assess and evaluate pedagogical usability, cross-cultural usability, and interface evaluation in technology-supported language teaching systems. Upon reviewing the existing literature pertaining to the usability of e-learning materials designed for the instruction of Turkish as a second language, two notable studies conducted by Goker (2019) and Ayhan (2019) emerge. In his 2019 study, Goker conducted an evaluation of the e-learning environment "3 Dakikada Turkce," which was specifically designed for teaching Turkish as a foreign language. The evaluation focused on many aspects of the e-learning system, including ease of navigation, design, accessibility, permanence, and efficacy. In a separate investigation, Ayhan (2019) employed the eye tracking technique to ascertain the cognitive ramifications of reading materials on learners in the context of teaching Turkish as a foreign language. The study also elucidated the role of these texts in Turkish instruction and the subsequent behaviors exhibited by learners. Based on the findings of both researches, it is evident that the determinants influencing usability encompass design characteristics, as well as individual and cultural variances.

Intercultural Usability

Usability evaluations necessitate the consideration of various variables by researchers and designers. The components encompassed in this framework consist of learner, technological, pedagogical, and cultural aspects. The integration of pedagogical and technological aspects of technology-based learning, including content, interface, learning environments, and learning tasks, is designed to facilitate the use of technical-pedagogical tools in order to help learners achieve their objectives (Silius et al., 2003). The consideration of intercultural usability is essential alongside technical and pedagogical usability in technology-supported language learning systems (Kukulska Hulme & Shield, 2006). The criterion of interculturality, when accompanied by pedagogical learning contents, should be taken into consideration in order to facilitate collaboration among users of other nationalities. Hence, it is imperative to acknowledge and consider the significance of cultural disparities in e-learning artifacts (Son & Park, 2014). Satar (2007) asserts that the evaluation of an e-learning application should encompass an assessment of its usability as well as its didactic effectiveness. The usability elements encompassed by e-learning objects encompass a range of factors, including navigation, accessibility, consistency, visual design, interaction, learnability, content quality, utilization of multimedia tools, learning strategy, provision of educational feedback, instructional evaluation, student assistance and support, and accommodation of learner diversity. To enhance the intercultural applicability of e-learning materials, it is imperative to take into account several variables, including age, gender, and culture, which are contingent upon individual disparities and learning preferences within the educational setting (Satar, 2007). The user, as the focal point of analysis, serves as the foundation for the usability factors pertaining to e-learning products. Designers and educators should take into account the requirements and desires of users. Typically, individuals utilize things in accordance with their specific requirements. The designers assess the functionality, emotional aspects, purpose, duration of usage, and design, while considering the users' requirements.

Furthermore, it is imperative that the developed goods align with the cultural framework of the intended users, necessitating the adoption of a culture-oriented design methodology. In contrast, Marwa et al. (2022) conducted a study that focused on the utilization of websites as educational tools for teaching foreign languages, specifically English. Their analysis centered on intercultural communication and competency within these websites, highlighting the significance of intercultural competence in English language instruction. According to Marwa et al. (2022), the utilization of e-learning objects that are designed in alignment with intercultural learning can effectively stimulate English learners to engage in communication and collaboration. These e-learning objects encompass a diverse range of authentic learning materials, including text, images, audio, and video, which offer illustrative instances from various cultural backgrounds (p. 160). Naidu et al. (2020) conducted a study investigating the impact of online interactive language learning tools, including FluentU, Duolingo, Livemocha, and Hello English, on the acquisition of English language skills. The researchers emphasized the importance of incorporating cultural elements into the user interface, such as color selection and font type, as well as ensuring the tools offer flexibility in their usage.

Hence, seemingly minute elements such as color and font selection can exert an influence on the cultural attributes of e-learning artifacts. In Zaharias' (2008) study, the impact of cultural factors, including gender and national culture, on the usability of e-learning tools was investigated. The study involved participants from Turkiye, Greece, Bulgaria, and Romania. The findings revealed that the incorporation of color, typography, and graphics within the e-learning platform, along with a streamlined navigation system devoid of excessive redirection and multiple links, was perceived as beneficial by individuals from various national backgrounds within the study group. The research findings also indicate that in cross-cultural usability tests, distinct cultural groups primarily prioritize on-site navigation.

Intercultural user interface design (IUID) is a recognized approach aimed at enhancing cross-cultural and intercultural usability. This design methodology encompasses the diverse requirements of many cultures, taking into account their customs and traditions. Designers diligently consider these variables to ensure an inclusive and culturally sensitive user experience (Heimgartner, 2019). As to Alexander et al. (2017), culture-oriented website design encompasses several key elements, such as navigation, links, page layout, visual representation, multimedia tools, color, and content. Satar and Morshidi (2007) underscored the significance of cultural disparities and dimensions in influencing usability, coining the term "culturability" to describe the intersection of culture and usability. Therefore, the user-friendliness of an e-learning system is influenced by cultural values. Due to cultural variations, diverse opinions can arise regarding several elements, including backdrop, colors, images, and animations. In the context of exploring the correlation between usability features and cultural dimensions, Satar (2007) employs a conceptual framework that incorporates Hofstede's cultural dimensions and Nielsen's usability characteristics. Heimgartner and Windl (2013) suggest that a distinction exists between the notions of "intercultural" and "cross-cultural". The concept of "intercultural" values pertains to the acquisition of knowledge through the observation and analysis of distinctions between two or more cultures. According to Gonzalez (2011), the term "cross-cultural" pertains to the examination of both the similarities and contrasts that exist between two distinct cultural groups. Individuals from South American cultures tend to derive pleasure from engaging in dancing activities during celebratory events such as birthday parties. Conversely, individuals from North American cultures tend to exhibit a preference for participating in culinary endeavors and engaging in casual conversations during similar social gatherings. A study with a focus on cross-cultural analysis is being conducted to examine this particular circumstance. The term "intercultural" pertains to the examination of the behaviors that arise when individuals from two or more distinct cultures engage in interactions.

Every year, a substantial number of individuals engage in cross-border travel, encompassing not just physical movement across states but also traversing linguistic boundaries. In contemporary society, individuals hailing from diverse cultural origins are compelled to coexist harmoniously. The significance of intercultural communication and cultural learning has become increasingly paramount in contemporary times. There is a growing recognition of the importance of accurately identifying, understanding, and instructing the diverse speech patterns linked to different languages and cultures (Wierzbicka, 2006). In their study on intercultural usability, Hacker and Mandl (2008) investigated the behaviors of internet users from Taiwan and Germany. They discovered that users from these distinct cultural backgrounds exhibited varying performances when engaging in the same task on a shared website. The researchers based their investigation on Hofstede's cultural dimensions. Previous research (Downey, et al., 2005; Heimgartner, 2013; Schmitz et al., 2008) has examined the relationship between culture and usability, specifically by investigating Hofstede's cultural dimensions and Nielsen's technical usability features. These studies have found that the level of individualism or sociability in a culture has an impact on the usability of products. Previous studies have noted that the utilization of e-learning systems that possess the ability to accommodate individual variances, exhibit flexibility, incorporate intercultural communication materials, and demonstrate awareness of sensitivities in intercultural interaction, can be employed (Kuhnt, 2002; Lee, 1999; Zaharias et al., 2001).

Hunaiyyan et al. (2008) discuss the various cultural elements that are considered in the context of e-learning. These elements encompass language, social dynamics, political factors, economic considerations, religious aspects, technical dimensions, learner characteristics in learning design, communication and interaction styles, learning strategies, multimedia-based interface, and graphic design. According to Heimgartner (2017), user interface elements can be categorized into two main groups: visible elements, such as typeface, color, and window size, and unseen elements, including interaction speed, information display, and search bar.

When assessing e-learning objects and content, it is crucial to consider socio-political factors, particularly the disparities between Asian and European cultures, sensitivities, interactions between countries with strained relations, as well as content-related aspects and diverse concepts such as color, region, and belief. Graphics and images play a significant role as the visual language of a certain culture. The development of culturally-specific user interfaces can be advantageous in using the insights and understanding of a particular culture. The field of intercultural user interface design encompasses various aspects such as cultural factors, human-computer interaction, intercultural values, user interface characteristics, and methodologies for designing interfaces that are based around culture. Human-computer interaction encompasses direct intercultural aspects.

In light of Son and Park's intercultural usability recommendations for e-learning environments, it is imperative for a website to possess certain characteristics in order to facilitate effective intercultural language learning. These characteristics include the presence of a broad interaction network, the inclusion of authentic materials, the provision of grammatical and cultural information, accompanied by examples that are applicable to daily usage in the target language, and the incorporation of elements that reflect the nuances of the target culture. It is recommended that educational settings provide opportunities for learners to engage in self-assessment, task-oriented activities, and avoid any potentially discriminatory components (Son & Park, 2014). In summary, it can be asserted that elements and contexts that demonstrate awareness of cultural distinctions, such as the user interface of e-learning platforms, choices regarding color and font, immediate access to the intended hyperlink, availability of multiple language options on the website, consideration of religious, linguistic, and ethnic identities, exemplify instances of intercultural usability in e-learning materials.

METHOD

Research Design

The present study employed a mixed methods research design, incorporating both qualitative and quantitative research methodologies, to assess the intercultural usability of the "Ana Dil Turkce" e-learning system. Mixed methods research designs enable researchers to leverage the respective advantages of quantitative and qualitative data. This study was deemed appropriate for the mixed method approach due to its capacity to facilitate a comprehensive examination through the utilization of qualitative data for in-depth analysis and quantitative data for generalization (Creswell & Clark, 2018; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2003; Yildirim & Simsek, 2018). The present study employed a research design known as a "concurrent mixed methods approach." This approach incorporates the simultaneous utilization of qualitative and quantitative data. The objective is to undertake a comparative analysis, amalgamate, integrate, and broaden the scope of the acquired data (Creswell, 2021; Yildirim & Simsek, 2018). The research employs a cross-sectional survey approach for the quantitative component, while a case study design is utilized for the qualitative component. The research approach employed in this study is referred to as a combination of qualitative and quantitative methodologies. The quantitative findings demonstrate the associations and patterns across variables, while the qualitative findings provide insights into the subjective experiences and perspectives of individuals. Consequently, this particular framework provides a comprehensive comprehension and facilitates the interpretation of the findings (Creswell & Clark, 2018; Kukla et al., 2015; McBride et al., 2018; Meixner & Hathcoat, 2019; Morse, 1991).

Participants

The research sample comprises individuals who are engaged in the acquisition of Turkish as a second language. These individuals have been registered in the system during the period spanning from 2020 to 2022, and they actively utilize the system. The quantitative sample of the study consisted of 211 students, whereas the qualitative sample comprised 25 students. The determination of the quantitative sample for this investigation was based on the random sampling method. The objective of this study is to make generalizations on Turkish language learners who utilize an online learning platform, based on the selected sample. Additionally, the study aims to minimize scope errors in the database and enhance the representational capacity. This research is supported by the works of Creswell (2021), Ilhan and Deniz (2021), and Tutar and Erdem (2020). The quantitative sample of the study consists of 211 participants who represent a diverse range of nationalities, originating from 50

distinct countries. The age range of the participants spans from 17 to 65 years. The selection of participants for the study's qualitative sample was based on purposive sampling, which aimed to capture a wide range of perspectives and experiences in order to gather comprehensive and reliable data. The purpose of purposeful sampling in qualitative research is to gather a comprehensive amount of data, with the intention of achieving the concept of "generalizability" (Creswell & Clark, 2018; Guba & Lincoln, 1982; Teddlie & Yu, 2007). The determination of sample size in qualitative studies is contingent upon the selected methodology. According to Nastasi and Hitchcock (2016), the recommended range for the sample size in qualitative research involving in-depth interviews is often between 10 and 30 individuals. In relation to the matter at hand, the study's qualitative sample encompassed a total of 25 individuals hailing from distinct countries, with ages ranging from 17 to 54 years. The participants willingly participated in the study. The research group, encompassing both qualitative and quantitative components, is discussed in the "Findings" section.

Data Collection Tools

Quantitative Data Collection Tool

In this study, as a quantitative data collection tool, a 5-point intercultural usability questionnaire consisting of 8 items graded in likert type was used. The questionnaire sections consist of gender, age, education level, experience in taking Turkish online education, ability to use online education tools, pedagogical, intercultural and technical-design usability categories. Internet and computer literacy of users in the was survey considered as a variable, therefore, related to online education technologies the category of usage skills and the experience of learning Turkish online items were prepared. The participants were questioned regarding their knowledge of using online learning resources and whether they had previously taken online Turkish courses. 48.3% (n=102) of the participants had never taken an online Turkish course previously, compared to 51.7% (n=109) of the individuals who had. The findings for the items related to the usage skills related to online educational technologies are shown in table 1. As a result of Cronbach Alpha used to examine the internal consistency between the test scores of this part of the questionnaire, α = ,741 was found.

Table 1. Descriptive Values Related to the Experience of Using Online Educational Technologies

Expressions	n	$\bar{x}$	s
I easily learn to use a new online training tool	211	3,78	1,095
I use online education resources to support my language learning	210	3,83	1,033
I use online educational technologies for problem-solving, critical thinking and developing my personal interests	211	3,66	1,063
I benefit from online education programs while doing my projects and assignments	211	3,68	1,104
I need help using online education tools	211	2,96	1,247
I use online education tools to reinforce the knowledge I learn in class	211	3,66	1,058

Upon examining the feedback provided by users of Ana Dil Turkce e-learning objects regarding their usage skills related to online educational technologies, it becomes evident that participants do not encounter significant challenges when utilizing new online tools. Instead, they predominantly employ online tools to facilitate language learning and enhance personal development and cognitive abilities. Notably, these technologies are particularly utilized as supplementary resources and for reinforcement purposes in educational settings. This scenario suggests that e-learning objects have the potential to serve as a means of bolstering formal education. Furthermore, it has been observed that individuals utilizing online educational resources often necessitate support either from the system itself or from external sources. Based on the provided data (mean = 2.96, standard deviation = 1.247), it was noticed that users require assistance, either online or offline, when utilizing online educational tools such as the Ana Dil Turkce e-learning system and other similar e-learning platforms. There is a demonstrated need for technical support services.

The survey encompasses many demographic variables, namely gender, age, nationality, education level, and a personal information form to gather pertinent data. During the development of the questionnaire, items pertaining to pedagogy, technology, and initial drafts were generated through an examination of relevant literature on the measurement of cultural usability (Hemard & Cushion, 2001; Lund, 2001; Lewis, 2002; Jeng, 2005; Nokelainen, 2006; Shield & Kukulska, 2006; Lim & Lee, 2007; Liu et al., 2008; Weninger, 2010; Son & Park, 2014; Chuah et al., 2016; Cagiltay, 2018;). Prior to administering the survey items via an online platform, a panel of seven experts was consulted to gather their perspectives. Subsequently, the survey items were revised and restructured based on the recommendations provided by these experts. Subsequently, the questionnaire items were administered to the 30 participants as part of the pilot project. Based on the perspectives of the participants, items that were considered unnecessary have been eliminated.

Qualitative Data Collection Tool

Interviewing is frequently used as a data collection tool, especially in the case study section of instructional design studies (Buyukozturk, et al. 2016). The questionnaire was composed of 6 primary and 5 secondary questions after the literature review. The structured interview form questions are as follows:

1. What do you think about the usability of the Ana Dil Turkce E-Learning platform?
    - What is your general opinion about the usability of the platform? Can you tell us about your expectations for the platform?
2. What are the features of the Ana Dil Turkce system that you think are useful?
    - Can you briefly explain the benefits of the platform according to you?
3. What are the negative experiences you have had in the Ana Dil Turkce system?
    - What are the problems you encounter when using the platform? (What are the reasons for the problems you encounter?)
        a) Which feature(s) of the system did you have difficulty(s) using?
        b) What kind of difficulty(s) did you experience?
4. What do you think about the effect of the e-learning objects in the Ana Dil Turkce system on your Turkish learning?
5. What do you think about continuing to use the system?
        a) What are your views on the design of the platform?
        b) How do you evaluate the platform as an educational environment?
        c) What are your opinions about the educational content on the platform?
6. What are your suggestions about the platform? How can the usability of the platform be improved?

The semi-structured interview form was rearranged after 7 expert opinions. Before proceeding to the data collection phase, scientific research and publication ethics permissions were obtained from the relevant institutions. Due to the COVID-19 pandemic, the entire data collection process was conducted online.

Data Analysis

Quantitative data analysis involves the utilization of statistical methods to describe and analyze data in research. Firstly, the responses of the participants were evaluated. Subsequently, any unanswered responses were eliminated. Subsequently, the descriptive statistics for variables and categories were determined, including frequency, quantity, percentage, mean, and standard deviation. The mixed method data analysis procedure involved the integration of quantitative and qualitative data to facilitate their joint interpretation. Specifically, the descriptive values of the questionnaire items were scrutinized. Additionally, in order to assess the survey's reliability, the Cronbach Alpha internal consistency reliability coefficient was calculated for each sub-dimension of the survey, as presented in Table 2.

Table 2. Intercultural Usability Items Cronbach Alpha Result

Category	Number of Items	$\bar{x}$	s	Cronbach Alpha α
Intercultural Usability	8	30,83	5,317	,848

According to Buyukozturk (2020), Cortina (1993), and Tutar & Erdem (2020), the Cronbach Alpha reliability internal consistency coefficient is deemed sufficient for the reliability of a measurement tool when it is 70 and above. Additionally, values between 80 and 1.00 are regarded as extremely dependable. Hence, it can be observed that the measurement employed in the study demonstrates the instrument's reliability as a measurement tool, encompassing its sub-dimensions of pedagogical and technical usability. The qualitative dimension of the study included content analysis, which is a sort of qualitative data analysis. The primary objective was to comprehensively comprehend the research data. Consequently, the integration of themes and categories was accomplished through a hierarchical structure. The initial phase of content analysis involved the coding of the data. The coding step of the content analysis employed the inductive method, as described by Creswell (2017), Strauss and Corbin (1990), and Saldana (2019). Following the consolidation and analysis of the codes, thematizations were conducted in order to elucidate the characteristics of the datasets and present comprehensible information. During the process of thematization, the identification of both similarities and differences in the data was undertaken. Various themes were established, including basic, primary, and secondary themes. The researchers employed the NVIVO 12 software tool to facilitate the procedures of theming and coding. The dependability of the determined themes and codes was assessed by obtaining the opinions of two experts. The data gathered in this study were assessed for reliability using the Miles-Huberman and Saldana model. Additionally, the themes identified in the data were analyzed by applying the same model to calculate the reliability coefficient. According to the study conducted by Miles et al. in 2014, it was found that... The internal consistency coefficient was found to be greater than 80%. Therefore, a consensus was reached between the perspectives of the expert and the researcher. The procedure of analyzing qualitative data was modified in accordance with Creswell's model, as depicted in Figure 1 (Creswell, 2017, p.197).

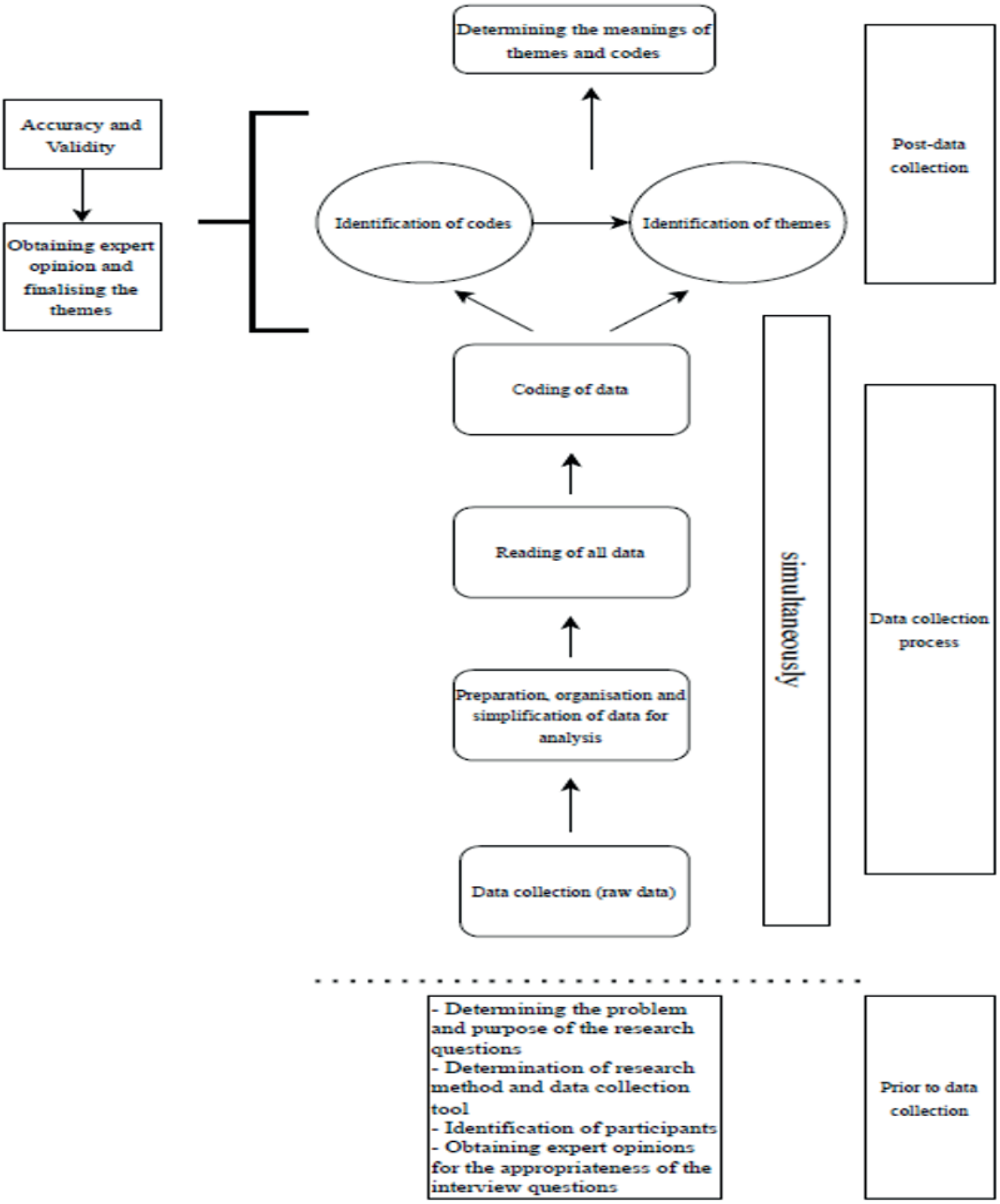

Figure 1. Qualitative Data Analysis Steps

In the process of data analysis, descriptive values of survey items and themes were compared in order to interpret qualitative and quantitative data according to the mixed method holistically.

FINDINGS

Quantitative Findings

Descriptive Data on Survey Participants

The average age of the survey participants is 27.41. Participants are from 50 different countries. It has been determined that most users come from the Middle East and Central Asian countries. The top 5 countries with the most system users are as follows: Syria (n:52, 24.64%), Kazakhstan (n:23, 10.90%), Iran (n:11, 5.21%) Egypt (n: 10), 4.74%) and Iraq (n:9, 4.27%). It has been determined that the countries with the least number of active users are European and American countries such as Germany, France, Belgium, Argentina, and Peru (n:1, 0.47%). Descriptive data regarding the survey participants are shown in the table 3 below:

Table 3. Information About Survey Participants

Variable	n	%
Gender		
Female	118	55,92
Male	93	44,08
Age		
17-24	110	52,1
25-34	53	25,1
35-44	29	13,7
45-54	16	7,6
55-65	3	1,4
Education Level		
High School	52	24,6
BA	106	50,2
MA	34	16,1
PhD	11	5,2
Others	8	3,8
Total	211	%100

Regarding Intercultural Usability Results

Upon examination of the descriptive statistics, it becomes apparent that the Ana Dil Turkce e-learning items provide a significant contribution to cultural learning. Based on user feedback, the e-learning objects within the system are seen to incorporate Turkish cultural representations, integrate cultural aspects alongside grammatical knowledge, and illustrate cultural distinctions. Table 4 presents the descriptive values according to the intercultural usability characteristics.

Table 4. Intercultural Usability Items on Survey and Descriptive Values

Expressions	n	x̄	s
There were elements representing Turkish culture	210	3,83	,873
There were intercultural tasks and practices	210	3,67	,914
Linguistic and cultural information was presented together	210	3,74	,955
There were examples of intercultural differences. (– such as traditions, courtesy rules, holidays…)	210	3,79	,935
The system enabled me to interested in the Turkish language and culture	209	3,79	,981
I had the opportunity to see the intercultural differences	210	3,75	,942
There was biased, racist and offensive language content	209	4,39	1,019
I learned new information about Turkish culture	209	3,85	,993

In addition, it is seen that the system does not have prejudiced, racist and offensive language contents (The questionnaire item of this statement was reverse-scored). This situation shows that the Ana Dil Turkce e-learning objects have a sensitive approach to different cultures and values. On the other hand, looking at the second item of expressions, it can be said that the system should be developed and updated to create an interactive and collaborative cultural learning environment ($\bar{x}$=3,67, s=,914).

Qualitative Findings

Descriptive Data on Interview Participants

In order to provide a high level of diversity in qualitative data in accordance with the target audience of the system and the average age, 25 different interviews via an online meeting platform (Zoom) with 25 participants from different countries have been carried out. The average age of the participants is 26.2. The countries of the users are Albania, Ukraine, Kyrgyzstan, Iran, Azerbaijan, Jordan, Uzbekistan, Afghanistan, Morocco, Egypt, Syria, Mongolia, Indonesia, Hungary, Russia, Georgia, Tunisia, Pakistan, Iraq, India, Poland, Costa Rica, Romania, Algeria, United States. The demographic and descriptive data of the interview participants are in table 5.

Table 5. Demographic and Descriptive Data of The Interview Participants

Variable	n	%
Age		
17-24	10	40,0
25-34	11	44,0
35-44	3	12,0
45-54	1	4,0
Gender		
Male	13	52,0
Female	12	48,0

Level		
A1-A2	5	20,0
B1-B2	13	52,0
C1-C2	7	28,0
Education		
High School	1	4,0
Bachelor	14	56,0
Master	7	28,0
PhD	3	12,0
Location		
Asia	14	56,0
Europe	5	20,0
Africa	4	16,0
North – South America	2	8
Total	25	100

During the course of the interviews, the technique of thinking aloud was additionally employed, whereby participants were instructed to interact with the system in real-time. Consequently, the researchers conducted observations on the participants' utilization of e-learning materials. Furthermore, the researchers also considered the ambient conditions in which the subjects were situated. As a result, inquiries were made regarding the intentions of learners in utilizing the system, taking into account the geographical location of the users, whether they reside within or outside the borders of Turkiye.

Intercultural Usability Themes and Codes Obtained from Interview Data

The researchers employed the method of inductive content analysis to get comprehensive insights from the collected interview material. Subsequently, the data was utilized to generate codes, which were then employed to establish themes (see table 6). The prominence of the instructional part of the system was highlighted based on the perspectives of the students. The pedagogical usability component of e-learning items encompasses two key aspects: action-oriented learning and appropriateness for the intended purpose. Consequently, it is imperative for an e-learning object to engage the student actively and elicit practical applications in everyday situations. The incorporation of culture into the content of e-learning objects is imperative, given its significant role in everyday language usage. Based on the perspectives of the students, it is evident that the e-learning objects incorporated within the system encompass course materials that are well-suited for the dissemination of Turkish cultural knowledge. Within the framework of interculturality, certain participants expressed the viewpoint that the Ana Dil Turkce e-learning items incorporate components derived from diverse cultural backgrounds. In the realm of cultural transfer, it is worth noting that while the Ana Dil Turkce learning objects are typically well-received by students, there exist certain inadequacies. In light of the feedback and recommendations provided by the students, it is advisable to enhance the cultural learning environment within the system. The students' expectations from an e-learning system include the presence of substantial and culturally diverse e-learning objects.

Table 6. Intercultural Usability Themes and Codes

Intercultural Usability			
Basic Theme	Primary Theme	Secondary Theme	Codes
Pedagogical Dimension	Action - Oriented Learning	Suitability for Purpose and Target	Course contents suitable for the transfer of Turkish culture
			Conformity to the cultural values of different languages and societies
Suggestions and Complaints	Learning Environment	Cultural Learning Environment	Cultural learning objects

Some of the learners opinions that created the "Course contents suitable for the transfer of Turkish culture" code are as follows:

> *"There are elements related to Turkish culture. I like these. For example, there were examples of Eid-al-Fitr and Eid-al-Adha. I learned cultural behaviours such as visiting elders and children kissing elders' hands."*
>
> *"There was information about Ataturk in the system and this helped me to get to know Turkiye."*
>
> *"I learned about the issues that Turks pay attention to on important religious and official days."*

According to the statements of the users, there are elements in the system that are suitable for the cultural values of different languages and societies. It is seen that users from the Turkish world find e-learning objects understandable and easy and users have high expectations in the context of cultural learning objects. Participants from Arab countries stated that they did not see any cultural barriers in their system, while participants from Western countries emphasised that the system should include more content on Turkish culture. Cultural learning objects, which are determined according to the opinions of the users and are missing in the system, can contribute to the development of e-learning content. Especially, content related to Turkish history, natural beauties in Turkiye, Turkish cuisine, music, and Turkish cinema should be added to the system. Examples of the statements of the participants are as follows:

> *"There was respect for the Arabic course contents, my language and my culture. I really like these features."*
>
> *"As an Uzbek, I felt comfortable using the system. Because many words and cultural features are common."*
>
> *"Eating, drinking, guest culture for Turkish culture, more content on points such as important people, Turkish architecture and Turkish classical music it could be. In this system, I also want to learn about Turkish culture."*
>
> *"The elements of Turkish culture can be increased even more. There are many points I wonder about regarding cities in Turkiye, foods, historical buildings and Turkish series. This system can be enriched cultural objects like these."*
>
> *"Current content, historical personalities, and information about Turkish culture should be more. There are good examples relating to words that can be used when communicating between people. But I think the number of content related to Turkish culture is not much. There should be promotional content for the culture. For example, Turkish TV series, Turkish movies, Turkish music and artists."*
>
> *"There should be more content related to Turkish culture. There are elements of Turkish culture but they are not enough. Content related to important figures of Turkish history such as Ataturk, Fatih Sultan Mehmet, Sinan the Architect should be created."*

When the opinions of users of e-learning objects are examined, it is seen that interculturality in foreign language teaching does not leave the pedagogical dimension. During the interviews, the participants especially emphasized the cultural dimension of e-learning objects. In order to determine the intercultural usability of the Ana Dil Turkce e-learning objects, qualitative and quantitative data were compared and examined (Table 7). According to the findings, the system is not in a biased, racist and aggressive structure. In addition, the contents are useful in the transmission of Turkish culture and intercultural interaction.

Table 7. Comparison of Intercultural Usability Qualitative and Quantitative Data

Qualitative Findings		Quantitative Findings	
Themes		Items	
Intercultural Learning Objects	Codes	Supporting Data $\bar{x} > 3,50$	Reparable $\bar{x} < 3,50$
Compatibility with cultural transfer and cultural differences	Course contents suitable for the transfer of Turkish culture	There were elements representing Turkish culture (3,83)	The number of intercultural tasks and exercises can be increased
	Conformity to the cultural values of different languages and societies	There were intercultural tasks and practices (3,67)	
		Linguistic and cultural information was presented together (3,74)	
		There were examples of intercultural differences. (– such as traditions, courtesy rules, holidays…) (3,79)	
		The system enabled me to interested in the Turkish language and culture (3,79)	
		I had the opportunity to see the intercultural differences (3,75)	
		There was biased, racist and offensive language content (4,39)	
		I learned new information about Turkish culture (3,85)	

Upon examination of the results, it becomes evident that the quantitative and qualitative data mutually reinforce and provide coherence to one another. According to the feedback provided by the interviewees, there is a suggestion to enhance the quantity of information and exercises that showcase Turkish culture within the system. The item "There were intercultural tasks and practices (3.67)" received a comparatively lower score compared to the other items. Hence, it is imperative to enhance the cultural e-learning items within the system. Upon careful examination, it is evident that the system does not contain any problematic elements such as racist, offensive language content, or graphics. The content labeled as "biased, racist, and offensive language" (4,39) underwent reverse itemization and yielded a significantly high score during analysis. The article titled "Linguistic and cultural information was presented together (3,74)" has been observed to have garnered satisfactory ratings and user feedback that supports this aspect. The aforementioned data has the potential to yield insights into the extent of content diversity inside the system, as well as the level of satisfaction experienced by users.

DISCUSSIONS AND CONSLUSION

The elements of intercultural usability in technology-assisted language learning systems necessitate the consideration of both technical and pedagogical usability. According to Kukulska Hulme and Shield (2006), Hence, the evaluation of Ana Dil Turkce e-learning items has been conducted within the framework of

intercultural usability of learning objects and the promotion of cultural awareness. Upon interpretation of the qualitative and quantitative data, it becomes evident that the system encompasses e-learning items that are well-suited for cultural learning. The cultural sensitivity of the e-learning objects within the system is evident. Pedagogical learning content has a crucial role in fostering interculturalism, facilitating collaboration among individuals from diverse national backgrounds. The evaluation criteria of cultural differences and learner diversity in e-learning objects are of paramount importance and should not be overlooked (Son & Park, 2014; Satar, 2007). Furthermore, it is recommended to augment the quantity of cultural learning materials available in Ana Dil Turkce and enhance their quality. In order to enhance the usability rating of an e-learning system, it is imperative that the material aligns with the principles of intercultural communication (Downey, 2005).

Liaw (2006) posits that foreign/second language learners make efforts to comprehend both the target culture and their own culture when utilizing websites designed for language instruction. Hence, there exists an interplay between the target culture and the dominant culture. Consequently, learners seek out shared aspects between the target culture and their own culture. Therefore, in the context of foreign language instruction, the development of e-learning materials should be based on the principles of universal intercultural communication and should align with the specific cultural aspects of the target language. During this interim period, it is possible to emphasize and compare the shared aspects between the dominant culture and the culture under examination. Furthermore, it is imperative that learning objects designed for intercultural usability are capable of establishing online environments that facilitate active learning, reflective thinking, need-oriented approaches, social engagement, and constructive and practical utilization (Son & Park, 2014; Liddicoat et al., 2003). When developing e-learning objects for the purpose of teaching Turkish as a foreign or second language, it is important to consider the following aspect.

The development and implementation of e-learning materials designed for the instruction of Turkish as a foreign language should aim to mitigate the challenges posed by linguistic and cultural differences for learners. In order to facilitate the effective utilization of cultural e-learning objects, it is imperative to situate them inside environments that offer flexibility for individual learners, allowing for personalized follow-up. Additionally, these environments should foster opportunities for social interaction among students, as highlighted by Liu et al. (2010) and Schat et al. (2021). Furthermore, it is imperative to consider the divergence in cognitive processes and epistemological orientations between learners from Western and Eastern cultures when designing learning materials (Jung, 2014). Manufacturers of learning objects must to possess a comprehensive understanding of the contrasting characteristics between individualistic and collectivist societies, particularly in the present context. The e-learning objects for the Turkish language should prioritize interactive resources that facilitate collaboration among learners from diverse cultural backgrounds, as well as independent learning.

The concept of intercultural usability refers to the intentional design of goods or services to facilitate the quick and effective utilization by individuals from diverse cultural backgrounds. This encompasses the customization of design elements and user interfaces to accommodate ethnic diversity in user preferences, expectations, and behaviors. In the contemporary era of globalization, the accessibility of products and services to individuals from diverse cultural backgrounds necessitates a heightened emphasis on intercultural usability. To ensure the accessibility and user-friendliness of their designs for a wide range of users, designers must possess an awareness of cultural factors that can impact usability. These factors encompass variations in language, color perception, spatial orientation, and social norms.

Examples of intercultural usability issues in design encompass the subsequent instances:

1. *Language:* Ensure that user interfaces are offered in a variety of languages and that proper use is made of language-specific fonts and character sets.
2. *Color:* Use color schemes that are appropriate for various cultural situations. Be aware of how different cultures perceive color and what it means.
3. *Navigation:* Use sensible, simple-to-understand navigation structures and iconography for people from many cultural backgrounds.
4. *Social norms:* Adapt user interfaces and interaction patterns in accordance with variations in social standards and cultural etiquette, such as preferences for direct or indirect communication.

The incorporation of intercultural usability has the potential to enhance user satisfaction, mitigate errors and misunderstandings, and ultimately enhance the overall user experience. When developing goods and services intended for a global market, it is imperative to consider various factors. Behavioral and cultural differences can give birth to a range of web usability concerns. E-learning objects have the potential to incorporate several variables, including color, visuals, expressions, icons, character sets, images, symbols, and time and date formats. The interpretation of a webpage may vary significantly among users from diverse cultural backgrounds. Certain metaphors have the potential to misconstrue and perplex visitors in terms of navigation, interaction, or the visual aesthetics of a website, and may even elicit annoyance.

One of the primary conclusions drawn from this study is the necessity for an increased provision of Turkish cultural content to cater to the needs of users. Furthermore, it may be argued that cultural learning objects serve as a vital element that enhances the pedagogical instruction of the Turkish language. Additionally, it is important to ensure that cultural learning objects in the Turkish language are adapted to facilitate interaction and collaboration. It has been noted that learners from the Turkic world exhibit a notable absence of challenges related to language and cultural barriers when utilizing e-learning resources. Nevertheless, in order to facilitate the widespread adoption of Turkish as a foreign or second language, it is imperative to extend its availability to Western nations with limited user bases. Additionally, these initiatives should aim to familiarize these groups with Turkish culture. Cultural learning items such as Turkish TV programs, music, Turkish food, Turkish architecture, and significant historical figures from Turkiye can be utilized as content for teaching Turkish culture and language. To ascertain the substance and technical shortcomings of the e-learning items within the system, it is important to carry out a periodic needs analysis.

Implications

General principles of intercultural language learning; It has developed on the concepts of sociocultural content, communication, instant interaction, learner and attitude towards learning. In order to improve the usability of websites prepared for foreign language learning in an intercultural context, the following points should be considered:

1. There must be specific and exclusive intercultural goals and examples of daily language use. Visual and audio content such as video, graphics, and text should be rich and diversity.
2. Cultural features, customs and traditions, special days and content that suggest social sensitivity should be included.
3. Content that will increase learners' interest in the target culture should be produced.
4. In addition to e-learning objects, instructors should interact with learners and conduct individual and group interviews.
5. Sensitive points such as language, religion, and race should be taken into account, and there should be no derogatory or racist elements.
6. When evaluating the general usability of foreign language learning objects and websites, technical, pedagogical, and intercultural usability concepts should be considered equally.
7. In intercultural usability studies, as much diversity as possible between experimental groups should be ensured.

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MAPPING THE RESEARCH AGENDA IN VIRTUAL REALITY STUDIES WITHIN EDUCATION

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ABSTRACT

This systematic literature review (SLR) scrutinizes the trends and interrelationships prevalent in Virtual Reality (VR) applications within educational frameworks, analyzing a comprehensive pool of 43 theses conducted in a Eurasian country. The primary objectives encompass investigating learning-teaching theories, learning domains, design elements, VR typology, and the departments undertaking VR research. Findings from the SLR underscore a significant concentration of VR research activities within technology-oriented departments. The prevalent approach involves experimental assessments of diverse variables within VR learning environments, yet a conspicuous dearth of design-centric investigations is observed. This highlights a critical need for comprehensive studies elucidating the design and developmental processes within VR applications, especially in light of the current characterization of VR research as lacking established standards. Moreover, a noteworthy revelation is the prevalent absence of a robust theoretical framework across the majority of studies. This absence may pose impediments to the widespread adoption of VR within educational paradigms, given the pivotal role of learning-teaching theories in guiding pedagogical processes. Examination of design elements highlights the prominence of realistic experiences, passive observation, mobility, and interaction with the environment. Recognizing the potential impact of diverse design elements on enhancing realism, aligning specific elements with distinct learning domains holds promise for augmenting the immersive quality of VR experiences. This research emphasizes the critical need for more comprehensive, theory-guided, and design-focused VR studies to propel its integration effectively within educational landscapes.

Keywords: Design element, learning domain, learning, theory, systematic literature review, virtual reality.

INTRODUCTION

Virtual Reality (VR) environments have seen rapid development in recent years, extending their use across diverse fields such as medicine, education, advertising, and gaming. The integration of VR technology beyond entertainment began in the 1980s, notably in vocational training like flight simulation (Hawkins, 1995). By the early 1990s, initiatives such as Science Space, Security World, and others paved the way for VR's introduction into K12 and higher education, offering educational advantages like three-dimensional visualization, tangible representation of abstract concepts, and the exploration of dynamic relationships within systems (Youngblut, 1998; Chen, 2007).

Numerous studies advocate for the integration of VR applications in education due to their ability to provide multiple perspectives and facilitate experiences otherwise constrained by factors like distance, time,

cost, or safety concerns (Alhalabi, 2016; Blyth, 2018; Koivisto, 2018). Existing literature has conducted comprehensive reviews on VR's educational impact, focusing on various databases, time frames, and specific variables (Chavez & Bayona, 2018; Radianti et al., 2020; Suh & Prophet, 2018; Wohlgenannt et al., 2019). For instance, Chavez and Bayona (2018) delved into VR's unique features in learning processes by surveying IEEE Xplore Digital Library, ScienceDirect, PsycINFO, and other databases. Radianti et al. (2020) explored immersive VR in higher education through examination of IEEE Xplore Digital Library, ProQuest, Scopus, and Web of Science databases. Similarly, Suh and Prophet (2018) focused on education, health, and marketing research on immersive VR using Scopus and Social Sciences Citation Index databases, while Wohlgenannt et al. (2019) reviewed immersive VR studies in higher education via the ProQuest database.

Despite these extensive reviews, the literature lacks research that examines the relationship between learning theories, domains, design elements, VR types, and departmental contexts across educational levels (K12, higher education, adult learning, etc.). Consequently, this research aims to discern current trends in VR applications within the education sector and investigate the correlations between the mentioned variables (learning theories, domains, design elements, VR types). The research questions determined for this purpose are listed below:

1. Departmental and Temporal Focus of VR Research in Education:
    - In which academic departments and during which time periods are VR research studies predominantly conducted within the field of education?
2. Research Methodology Preferences in VR Education Studies:
    - What are the prevalent research designs, participant demographics, data collection methodologies, and analytical approaches favored in VR research within educational contexts?
3. Preference for VR Types and Technologies in Education:
    - Which specific types of VR and technological platforms are commonly preferred and utilized in educational VR research?
4. Investigated Learning Domains in VR Education Studies:
    - What specific learning domains or subject areas are frequently studied within the realm of VR research in education?
5. Underlying Learning-Teaching Theories in VR Education Studies:
    - Which pedagogical and learning theories serve as foundational frameworks for VR research conducted in educational settings?
6. Preferred VR Design Elements in Education:
    - What are the primary design elements and features that are commonly emphasized and favored in VR research within educational contexts?
7. Relationship between Departmental Context and Research Design:
    - How does the departmental affiliation of researchers conducting VR studies in education correlate with their chosen research methodologies and designs?
8. Correlation between Department and Investigated Learning Domains:
    - What connections exist between the academic department affiliations of VR researchers in education and the specific learning domains or subject areas they investigate?
9. Alignment between Department and Learning-Teaching Theory:
    - Is there a discernible relationship between the academic department where VR education research is conducted and the theories of learning and teaching employed in these studies?
10. Association between Design Elements, VR Type, and Learning Domains:
    - How are the preferred design elements in VR education research associated with the chosen type of VR technology and the specific learning domains being explored?

These refined research questions aim to provide a clearer understanding of the interdisciplinary aspects, methodological preferences, theoretical frameworks, and thematic alignments within VR research conducted

in educational settings. By addressing these questions, this study endeavors to contribute to a comprehensive understanding of the multifaceted impact and utilization of VR technology.

THEORETICAL BACKGROUND

Virtual Reality

Technologies that facilitate user interaction within simulated environments, providing a sense of physical and mental presence, constitute VR (Dogan & Sahin, 2023). VR encompasses two primary categories: Nonimmersive VR and immersive VR. Nonimmersive VR involves users accessing virtual environments through conventional interfaces like keyboards, mice, and monitors. Conversely, immersive VR utilizes technologies like cave automatic virtual environments (CAVEs) or head-mounted displays (HMDs) equipped with motion tracking systems, enabling users to fully engage with the virtual world while disconnected from the physical environment (Wojciechowski & Cellary, 2013).

The VR name was created by Lanier and proposed in the early 1980s (Chavez & Bayona, 2018) The Gartner hype cycle, which represents the maturity, adoption, and social application of certain technologies, first demonstrated VR in 1995 during the peak of inflated expectations period (Figure 1). While VR navigated the trough of disillusionment until 2016, it gradually advanced into the slope of enlightenment in 2016 and 2017. This evolution underscores VR's trajectory from initial hype to more realistic expectations and maturation within technological landscapes.

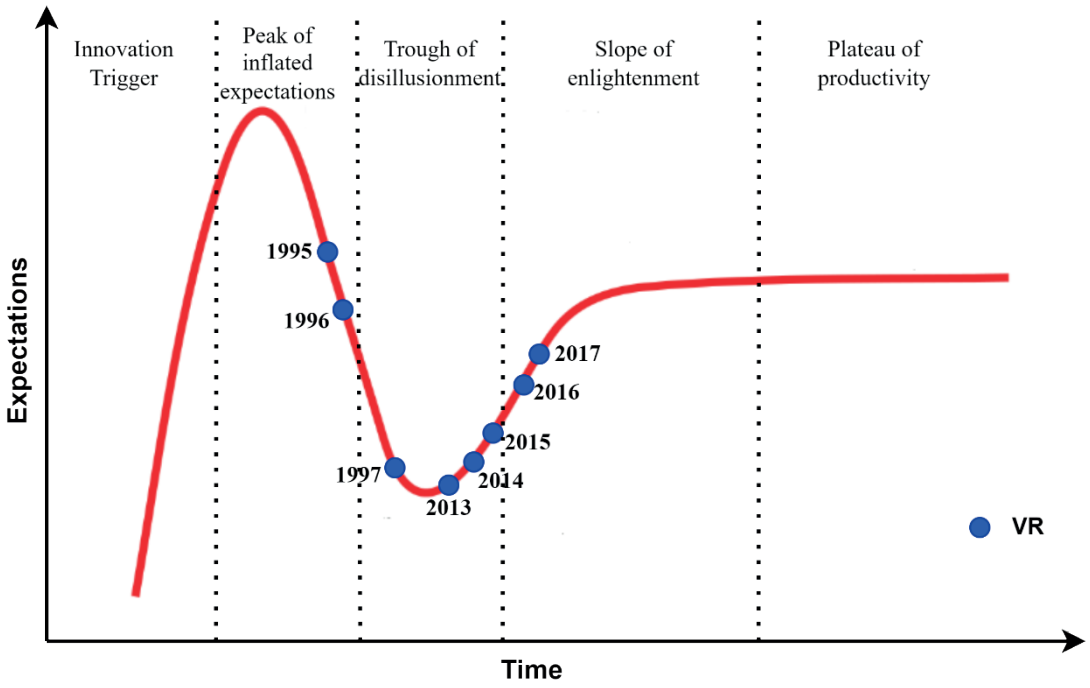

Figure 1. VR's position in the hype cycle (https://www.gartner.com/en)

In the Gartner hype cycle, each phase represents distinct stages in the adoption and perception of a technology. The peak of inflated expectations phase occurs early after a technology's launch, characterized by extensive exploration and evaluation. During this time, unsuccessful applications often outnumber successful ones. The subsequent phase, the trough of disillusionment, signifies dwindling interest in the technology, and its survival depends on successful applications that sustain demand. Moving forward, the slope of enlightenment marks a period of clarity regarding the technology's benefits. As illustrated in Figure 1, VR initially emerged as a new technology with predominantly unsuccessful applications between 1995 and 1996. Subsequently, between 1997 and 2015, it experienced a decline in user interest. However, in 2016-2017, VR was recognized for its utility and potential.

Projections in 2017 anticipated VR's transition to the plateau of productivity within 2-5 years, indicating its imminent adoption by larger masses—highlighting the significance of research conducted during this period. This forecast underscores the critical importance of studying VR during its transformative phase, poised for widespread utilization in contemporary times.

Learning Domain

Various classifications outline the domains in which the learning process unfolds. Gagne (1972) categorizes learning domains into motor skills, verbal knowledge, intellectual skills, cognitive strategies, and attitudes. Acquiring motor skills involves repetitive practice, while retaining verbal information necessitates organized and contextually meaningful presentation. Intellectual skills encompass not just learning a definition but employing it effectively. Cognitive strategies evolve as learners practice recalling, identifying, and problem-solving, whereas attitudes develop gradually through observation and experience.

During the learning process, activities often aim to develop multiple learning domains. To facilitate a more practical discussion of these domains, they are elaborated as declarative knowledge, problem-solving, procedural knowledge, soft skills, language acquisition, and behavioral impacts. Declarative knowledge comprises theories, facts, and data—typified by materials like textbooks—and is required for verbal knowledge and intellectual skills. Procedural knowledge, on the other hand, involves the application of declarative knowledge (Kochin et al., 2005), encompassing insights into domains like motor skills and cognitive strategies. Problem-solving cultivates analytical skills, critical for intellectual skills and cognitive strategies. Soft skills relate to communication and collaboration, while language acquisition intertwines declarative, procedural, and soft skills. Behavioral impacts align with attitudes and elucidate individual behavioral changes. Makransky and Petersen (2021) assert that VR enhances factual knowledge (akin to declarative knowledge) through its immersive, controlled, and faithful representations. It also facilitates conceptual knowledge (a more intricate form of declarative knowledge), procedural knowledge, and transfer of learning (encompassing all domains). However, for comprehensive development across these learning domains, the design and implementation of VR applications in education necessitate a strong theoretical foundation.

Theoretical Foundations in VR Applications

Mulders et al. (2020) presented a framework rooted in the cognitive theory of multimedia learning, offering guidelines for leveraging VR within learning environments. According to this framework:

1. Immersion and Learning Purpose: Optimal immersion levels in the virtual environment should align with the learning objectives. If high immersion does not serve the learning purpose, a lower level should be preferred.
2. Learning-Oriented Interactions: Virtual environments should facilitate learning-centric interactions to enhance educational outcomes.
3. Task Complexity Management: Complex tasks within the virtual environment should be deconstructed into smaller, more manageable units to support learning effectiveness.
4. Guidance and Information Provision: Adequate information and guidance must be available within the virtual environment to aid learners' understanding and progress.
5. Knowledge Integration: New information presented in the virtual environment should be balanced with and built upon learners' existing knowledge to foster deeper understanding.
6. Constructivist Learning Activities: Emphasis should be placed on constructive learning activities wherein learners play an active role in constructing knowledge.

Constructivism, central to this framework, asserts that knowledge is actively constructed rather than passively transferred. Students take an active role in their learning process, exploring and managing the learning environment (Duffy & Cunningham, 1996; Johnson & Johnson, 1996; Jonassen, 1992; Jonassen, 1999). 3D virtual learning environments offer a transparent interface, allowing direct user control over the virtual world (Hedberg & Alexander, 1994), a pivotal aspect supporting the constructivist learning paradigm.

Moreover, Dalgarno and Lee (2010) emphasize that VR, with its high representational fidelity and interactive features, provides significant opportunities for experiential learning. The constructivist paradigm encompasses theories like experiential learning, discovery learning, situated learning, self-regulated learning, scenario-based learning, game-based learning, and flipped learning (Bruner, 2009; Kolb, 1984; Lave, 1991; Prensky, 2003; Sams & Bergmann, 2013; Schraw, 2010). This diversity of theories underscores the robust theoretical foundation that can underpin VR research and applications. In addition to delineating learning domains and theoretical frameworks, the selection of design elements for VR applications plays a crucial role in ensuring their effectiveness within educational settings.

Design Elements

When exploring theories, models, and frameworks pertaining to the design of virtual environments, several prominent elements emerge (Chavez & Bayona, 2018; Dogan & Sahin, 2023; Makransky & Petersen, 2021; Mulders et al., 2020; Radianti et al., 2020; Suh & Prophet, 2018; Wohlgenannt et al., 2019):

- Immersion,
- Presence,
- Realism,
- Interactivity,
- Usability,
- Feedback,
- Media richness,
- Moving ability,
- Informing,
- Virtual awards,
- Assembling,
- Making meaningful choices,
- Role management,
- User generated content,
- Knowledge test,
- Aesthetic, ergonomic and universal design.

Upon analysis, the incorporation of the aforementioned elements into VR applications is intricately linked to the level of immersion these applications offer. Consequently, it becomes crucial to establish correlations between the learning domain, theoretical underpinnings, design elements, and the type of VR (immersive or nonimmersive) within VR research.

METHOD

Research Design

To fulfill the research objectives, a Systematic Literature Review (SLR) was conducted. SLR stands as a meticulous, transparent, and replicable approach aimed at identifying, synthesizing, and evaluating a collection of completed scientific research (Fink, 2005; Okoli & Schabram, 2010). This method enables the synthesis of evidence from research, facilitating the identification of research gaps (Petticrew & Roberts, 2006). The term systematic in SLR signifies adherence to a structured process governed by specific rules, emphasizing objectivity, transparency, and repeatability (Boell & Cecez-Kecmanovic, 2015). Recommended steps for conducting an SLR involve (1) determining the purpose, (2) creating a review protocol and training reviewers, (3) literature search, (4) screening for inclusion, (5) screening for exclusion, (6) data extraction, (7) synthesis of studies, (8) writing the review (Okoli & Schabram, 2010). Each of these steps encompasses specific operations, detailed under the respective headings to delineate the comprehensive methodology employed in this SLR.

Purpose of the Study

The primary objective of this SLR is to discern the prevailing trends within VR research in the field of education. Additionally, it aims to investigate the correlations and interdependencies between design elements, learning domains, research methodologies, and learning-teaching theories prevalent in these studies.

Creating the Review Protocol and Training Reviewers

At this stage, researchers outlined the designated database to conduct the SLR aligned with its intended objectives. They established stringent criteria that each study must meet to qualify for inclusion. Additionally, researchers delineated specific thematic focuses within the studies, emphasizing technologies, research methodologies, learning domains, learning-teaching theories, and design elements utilized in VR applications within the educational context. Consequently, these researchers drew insightful inferences regarding these thematic elements derived from the comprehensive literature review.

Literature Search

The research scrutinized masters and doctoral theses conducted in Turkiye, employing the National Thesis Center of the Council of Higher Education as the primary database during the literature search phase. This repository encompasses theses completed across universities in Turkiye, ensuring comprehensive access to relevant sources aligned with the research objectives. Hence, it can be stated that the study has accessed all pertinent sources essential for fulfilling its research aims.

Screening for Inclusion and Exclusion

The inclusion criteria for the SLR required studies to pertain to the field of education and encompass VR applications. Initially, a keyword search for "virtual reality" within the National Thesis Center yielded 943 master's and doctoral theses conducted between 1996 and 2023. Subsequently, a filtering process focusing on the "education and training" research subject reduced the pool to 106 studies. Researchers further scrutinized these studies, excluding descriptive, screening, and meta-analysis studies, as well as those lacking a VR application. Following this curation, a total of 43 theses (comprising 19 doctoral and 24 master's theses) met the criteria and were included in the SLR.

Data Extraction

In the data extraction stage, the researchers extracted the following data regarding the 43 studies identified in the previous stage:

- Year
- Department
- Research design
- Participants
- Data collection tools
- Analysis methods
- VR technology
- Learning domain
- Learning-teaching theory
- Design elements

The study classified the VR technology into two categories: immersive and nonimmersive, and categorized the hardware used into subsets such as HMD, HMD sets, mobile, and desktop. To ascertain the learning domain served by the VR applications, a coding system aligned with the framework established by Radianti et al. (2020) was employed (Table 1). Notably, while coding according to this framework, the data also revealed patterns in the grouping of learning-teaching theories (Table 2).

Table 1. Learning domain examples

Domain	Example
Problem-solving	Solving a math problem, coding a computer program, or deciding which medication to give a patient
Soft skills	Speaking in public, working in teams
Procedural knowledge	Knowing how to prepare operating room sets, learning fire extinguishing procedure
Declarative knowledge	Learning the names of underground mines, listing the names of the planets
Learning a language	Learning listening, writing and speaking skills for a foreign language
Behavioral impacts	Developing motivation and attitude (etc.) towards a course

According to Table 1, the learning domains addressed by VR applications are listed as problem-solving, soft skills, procedural knowledge, declarative knowledge, learning a language and behavioral impacts.

Table 2. Learning theories/approaches

Theory	Definition
Constructivism	Learner; makes sense of the environment he lives in by comparing, combining and structuring old and new information he has learned (Appleton, 1997).
Experiential learning	Learner; directly acquires and applies knowledge, skills, and emotions in an authentic learning environment (Kolb, 1984).
Multimedia learning	Learner; better understand, process, and remember information by incorporating multimedia elements that involve multiple sensory channels (Mayer, 2009).
Self-regulated learning	Learning occurs when planning, monitoring and controlling abilities are combined (Schraw, 2010).
Distance education	Learning takes place through media in an environment where learners and teachers do not meet face to face (Holmberg, 2005).
Scenario based learning	It is a learning approach in which the learner is an actor, and the achievements are constructed within the framework of a scenario (Veznedaroglu, 2005).
Behavioral skills training	It is the process of acquiring behavioral skills by following the steps of teaching, modeling, rehearsal and feedback in learning environments where the learner is active (Himle & Miltenberger, 2004).
Game-based learning	It improves the acquisition of knowledge and skills through game content and game playing, and game activities provide players (learners) with the opportunity to solve problems (Prensky, 2003).
Flipped learning	It allows educators to modify traditional classroom environments to introduce course content and learning outcomes to learners before meeting in the classroom and use classroom time to guide each student through active learning experiences (Sams & Bergmann, 2013).
Task based language teaching	Instructional tasks are intended to be authentic, and the activities designed consist of real-world tasks that learners are expected to perform outside the classroom (Bygate, 2016).
Discrete trial training	It is based on the principle of teaching appropriate behavior to the child by applying consecutive trials consisting of the premise of the behavior, the behavior and the result of the behavior (Tarbox & Najdowski, 2008)

Table 2 presents a comprehensive overview of 12 distinct theories underpinning the utilization of VR applications within the learning-teaching processes as observed in the studies encompassed by the SLR. Moreover, data detailing the design elements encapsulated within VR applications have been coded according to frameworks outlined by Dogan and Sahin (2023) and Radianti et al. (2020), elucidating the various structural components (Table 3).

Table 3. Design elements

Design element	Description
Realistic experience	Realistic design of characters, environment, voice-over, animations and scene transitions.
Interaction with environment	Creating a structure that allows basic interaction with characters and objects in the virtual environment.
Interaction with other users	Ability to interact with users in the virtual environment with their own virtual characters.
Informing in virtual environment	Presenting information about the application in a virtual environment, such as a tutorial or FAQ.
Making meaningful choices	Having a scenario shaped according to the user's choice.
Feedback	The user receives visual, auditory or haptic feedback from within the virtual environment.
Knowledge test	There is a structure within the VR application that allows the learner to evaluate himself.
Virtual rewards	Incorporating a reward system with virtual objects for tasks performed in the virtual environment.
Passive observation	Just following a stream of events in the virtual environment, no interaction.
Moving around	Being able to move in the virtual environment with physical movements or a game controller.
Role playing	Performing any role by the user in tasks prepared within a scenario.
User generated content	Apart from the virtual objects already existing in the virtual environment, users can also create new objects.
Screen sharing	Users can share their virtual environments with other users.
Assembling objects	Virtual objects can be transformed into new forms by combining and separating them.

Table 3 showcases the coding of data related to the design elements present within the VR applications examined for this SLR, categorizing them into 14 distinct categories. Furthermore, the evaluation of research designs, participant demographics, data collection tools, and analysis methods employed in the studies were conducted using established methodologies widely recognized in the literature (Table 4).

Table 4. Research designs, participants, data collection tools, data analysis

Research design	Description
Experimental research	Quantitative research, consisting of experimental and control groups, in which changes in the dependent variable are observed by intervening in the independent variable, and aiming to determine the cause-effect relationship.
Qualitative research	Research that reports narrative data on why and how a phenomenon occurs, using methods such as case studies and phenomenology.
Design and development research	Research that collects data through stages such as planning, design, implementation and development and reports the entire process.
Single subject research	Research that determines the cause-effect relationship by examining the changes in single subject over time and depending on the intervention.
Participant	Description
K-12	Students from kindergarten to 12th grade
Higher education	Undergraduate, master's and doctoral students
Teacher	Participants who teach in K-12
Expert	Participants who have a bachelor's, master's or doctoral degree in a subject
Adult	Participants who are over 18 years old but are not students
Data collection tool	Description
Test	Tools that are mostly multiple choice and measure success etc. (success testing, usability testing, etc.)
Scale	Valid and reliable tools used to measure structures that are mostly related to the affective domain, such as motivation

Survey	Tools that are used to quantitatively determine opinions on a subject, may include items such as multiple choice, open-ended, and graded, and whose construct validity is not required.
Interview	Tools generally used in qualitative designs that aim to determine participants' opinions through structured or unstructured questions.
Observation	Tools used to determine participant behavior and relationships by observing them.
Research diary	Tools based on data recorded by the researcher or participants regarding a topic during the research process.
Log	Tools that can store all kinds of data regarding participant behavior (lesson duration, attendance record, etc.), usually kept by an information system.
Rubric	These are tools that help determine participant data within specified criteria.
Document	Tools that provide valuable information (visual, audio, etc.) to understand the situation addressed in the research.
Data analysis	Description
Parametric	Analyzes aimed at determining the relationship between variables or the difference of the variable according to groups (e.g ANOVA, regression), depending on the prerequisite of ensuring various assumptions for the data set (normal distribution, etc.).
Nonparametric	Analyzes aimed at determining the relationship between variables or the difference of the variable according to groups when the prerequisites of parametric analyzes are not met (Mann Whitney U, Friedman, etc.).
Descriptive statistics	Analyzes aiming to obtain information about the distribution of a data set through measurements such as mean and standard deviation.
Descriptive analysis	Deductive approach used in the analysis of qualitative data when themes are predetermined.
Content analysis	Inductive approach to the analysis of qualitative data in which themes are revealed during analysis.

Upon reviewing Table 4, it becomes apparent that the studies included in this SLR were categorized based on four distinct research designs, encompassing five participant groups, utilizing nine varied data collection tools, and employing four diverse data analysis methods.

Synthesis of Studies

In this phase, researchers convened to engage in discussions, organize, and compare the gathered results. The objective was to achieve a comprehensive and coherent synthesis of information as advocated by Okoli & Schabram (2010). As articulated by Webster and Watson (2002), this synthesis stage entails a shift toward a concept-centered focus, involving the amalgamation of similar features within the data obtained. Hence, the researchers collaboratively organized the data extracted from the studies encompassed in the SLR, constructing a conceptual map aligning with the research questions. To achieve this, percentage calculations, frequency analyses, and cross-tabulations were employed, facilitating the visualization of results through pie charts, line charts, and bubble charts.

Writing the Review

The concluding stage involved a detailed and comprehensive report outlining the entire SLR process. This entailed establishing the relationship between the research gap and the research objectives, specifying the suitable database used for the inquiry, explicating the inclusion and exclusion criteria, elucidating the frameworks and rationales underpinning the data extraction stage, and outlining the methodologies employed for data analysis. The aim was to provide a comprehensive account of the entire SLR process, meticulously detailing each step taken in conducting the review.

RESULTS

The analyzes carried out to answer the research questions are presented in the form of graphs. Explanations of abbreviations in bubble charts are given in Table 5.

Table 5. Abbreviation in bubble charts

Abbreviation	Definition
Department 1	Instructional/Educational technology
Department 2	Science education
Department 3	Special education
Department 4	Educational science
Department 5	Mathematics education
Department 6	Primary school teaching
Department 7	Physical education and sports teaching
Department 8	Graphic education
Department 9	English language teaching
Department 10	Social sciences teaching
Department 11	Turkish teaching
Department 12	Management information systems
Design 1	Single subject research
Design 2	Design and development research
Design 3	Qualitative research
Design 4	Experimental research
Domain 1	Behavioral impacts
Domain 2	Learning a language
Domain 3	Declarative knowledge
Domain 4	Procedural knowledge
Domain 5	Soft skills
Domain 6	Problem-solving
Theory 1	Constructivism
Theory 2	Experiential learning
Theory 3	Multimedia learning
Theory 4	Distance education
Theory 5	Discrete trial teaching
Theory 6	Behavioral skills training
Theory 7	Flipped learning
Theory 8	Game based learning
Theory 9	Self-regulated learning
Theory 10	Scenario based learning
Theory 11	Task based language teaching
Element 1	Realistic experience
Element 2	Passive observation
Element 3	Moving around
Element 4	Interaction with environment
Element 5	Assembling objects
Element 6	Interaction with other users
Element 7	Role playing
Element 8	Screen sharing
Element 9	User-generated content
Element 10	Informing in virtual environment
Element 11	Feedback
Element 12	Knowledge test
Element 13	Virtual rewards
Element 14	Making meaningful choices

Figure 2 illustrates that among the 43 studies reviewed in this SLR, a majority were conducted within the instructional/educational technology department (n=17) and the science education department (n=11). Following closely are departments such as special education (n=3), educational science (n=2), mathematics education (n=2), and primary school teaching (n=2), respectively.

Additionally, individual studies were identified within specific fields such as physical education and sports teaching, graphic education, English language teaching, social sciences teaching, Turkish teaching, and management information systems, each representing a solitary study within this SLR. Notably, Ceken's study (2023), despite being conducted within the management information systems department, was included in this review due to its substantive focus on the impact of virtual reality on learning outcomes, aligning closely with the SLR's thematic focus.

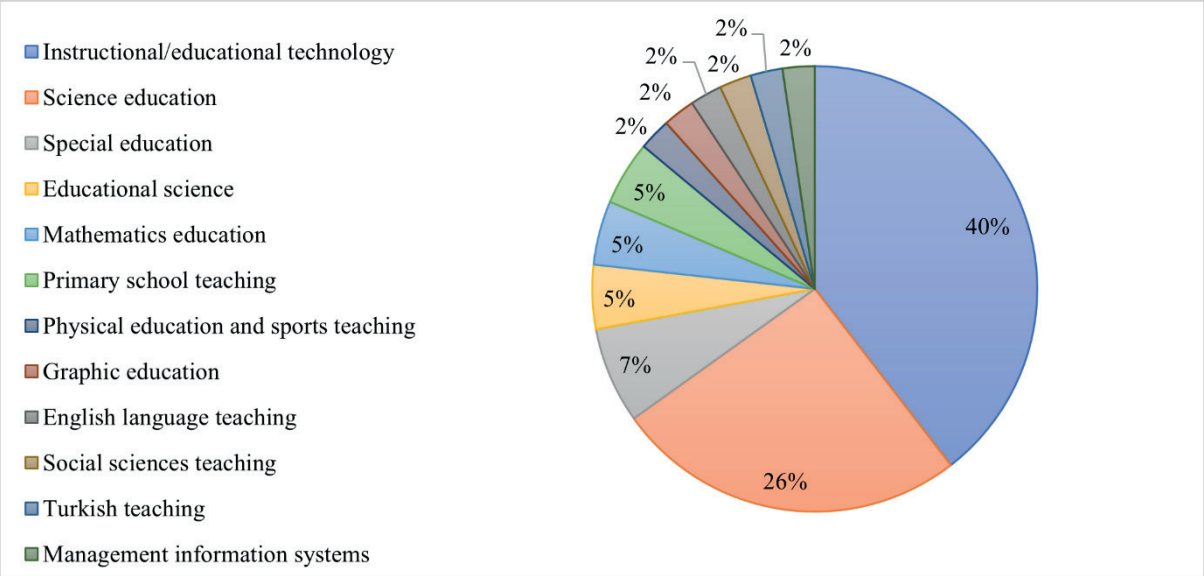

Figure 2. Distribution of VR research according to department

It was determined that studies on the use of virtual reality in education started in 2011 (Figure 3). Until 2017, there were a few master's thesis and PhD dissertations on the subject, but it has been observed that this number has increased since 2018. While the increase in the number of studies was noticeable in 2019 (n=10), there have been a total of 15 VR studies conducted in the field of education in the last two years (2022-2023).

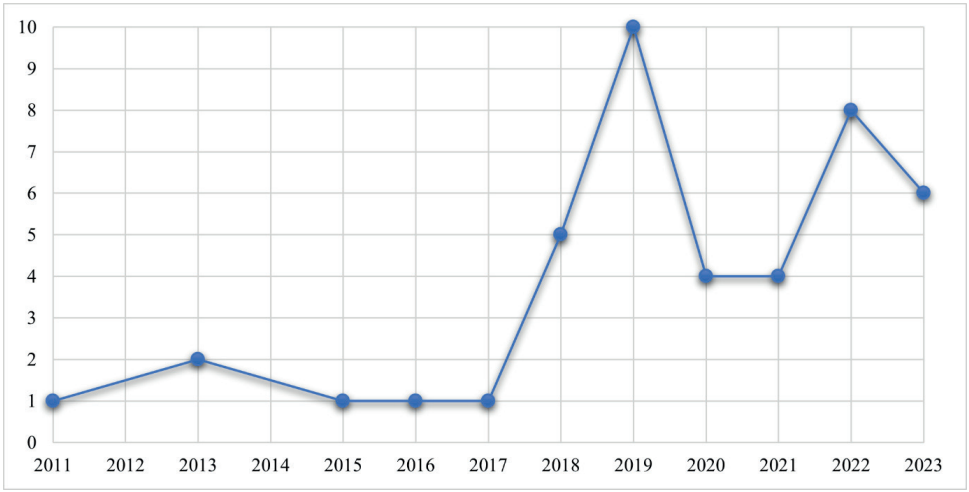

Figure 3. Distribution of VR research according to year

Figure 4 demonstrates the distribution of VR studies based on research design, showcasing a prevalent preference for experimental (n = 23) and qualitative (n = 18) methodologies. Notably, 11 studies (Abdusselam, 2022; Akbiyik, 2020; Akman, 2019; Bozdemir, 2022; Dogdu, 2023; Durukan, 2018; Guler, 2021; Gunduz, 2022; Kalkan, 2020; Ozonur, 2013; Saricam, 2019) employed mixed methods, integrating both experimental and qualitative designs. Additionally, four studies pursued design and development research methodologies. Furthermore, Kurtca's study (2021) was specifically structured on the basis of a single subject research approach.

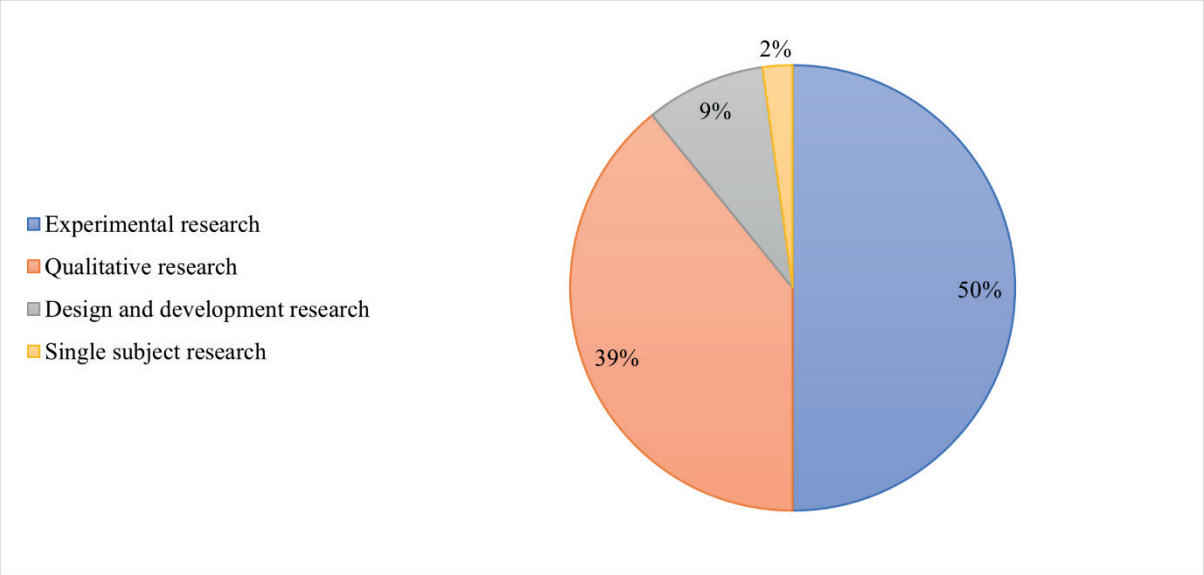

Figure 4. Distribution of VR research according to research design

Analysis of participant groups involved in VR research reveals a predominant focus on participants at the K12 level (n=21) and higher education level (n=18), as depicted in Figure 5. Notably, research conducted with experts amounted to two studies, while studies involving adults and teachers were limited to one each.

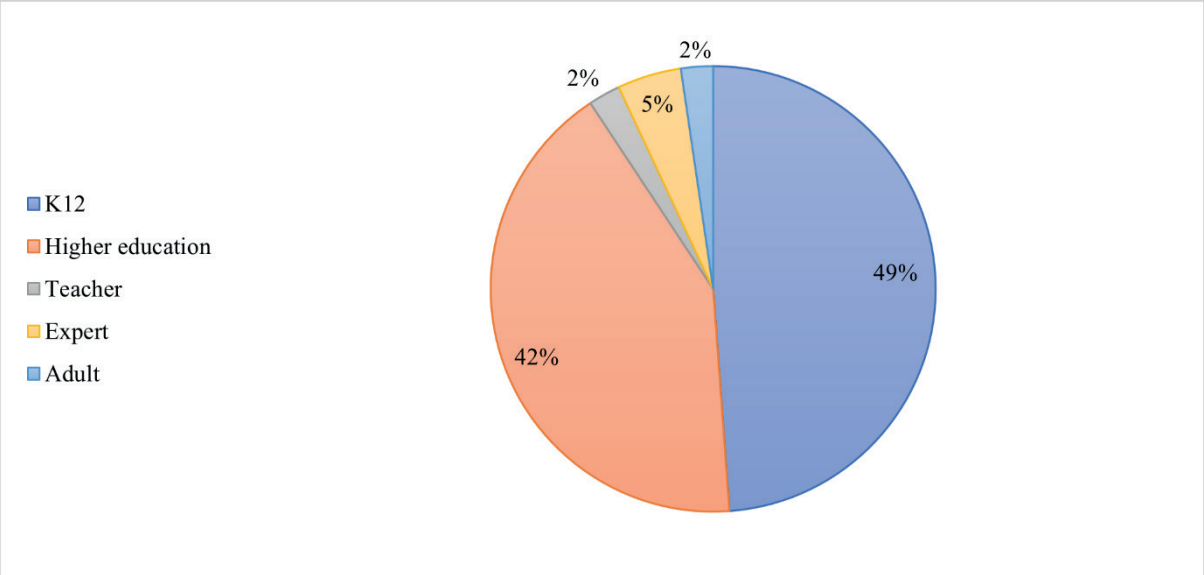

Figure 5. Distribution of VR studies by participant group

Figure 6 presents an overview of data collection techniques employed in VR research, indicating a balanced usage of both quantitative and qualitative approaches. Notably, the most favored data collection tools include tests (n=28), scales (n=28), and interviews (n=27). Conversely, less commonly utilized methods comprise documents (n=4), research diaries (n=3), system logs (n=3), and rubrics (n=3). Additionally, observations (n=14) and surveys (n=7) were also employed as data collection methods across several studies.

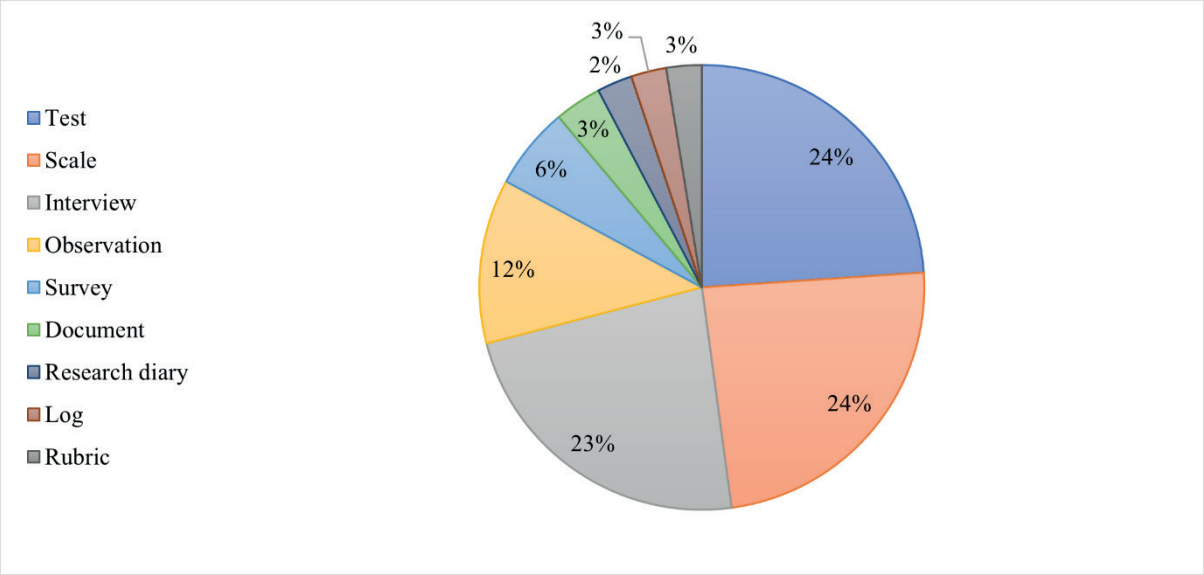

Figure 6. Distribution of VR research according to data collection tool

Figure 7 categorizes the data analysis methods employed in research into five distinct groups. Parametric test statistics emerged as the most preferred analysis method (n=28), closely followed by content analysis (n=18), descriptive statistics (n=14), nonparametric test statistics (n=12), and descriptive analysis (n=10).

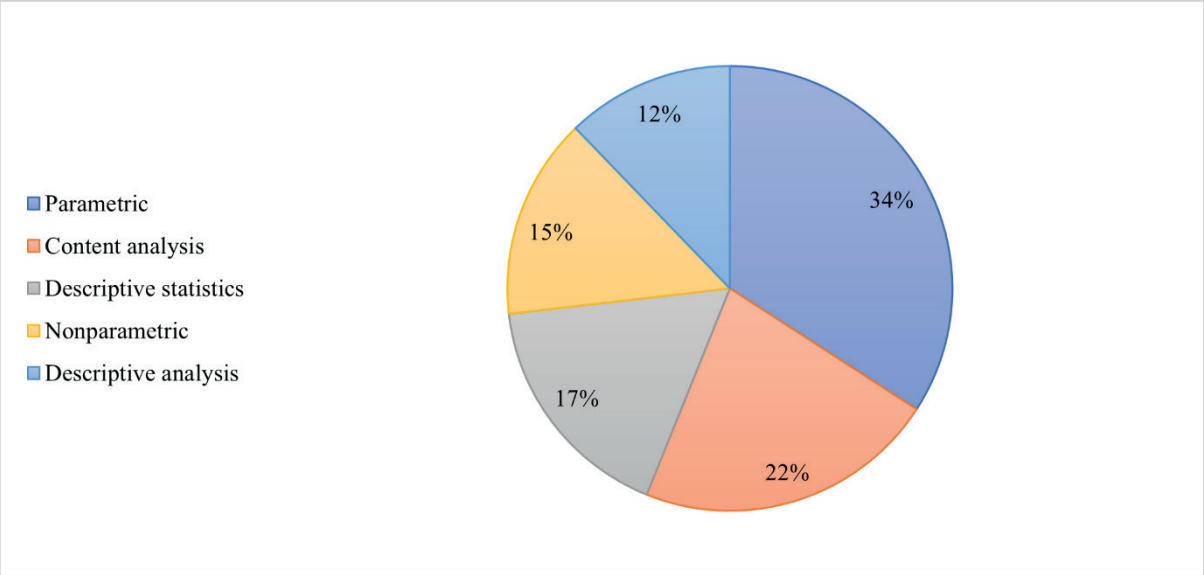

Figure 7. Distribution of VR research by data analysis

Figure 8 illustrates a notable distribution among the studies included in the SLR based on VR type, revealing a substantial preference for immersive VR (n=37). Conversely, nonimmersive VR was employed in the research process in only five studies, while one study lacked specific information regarding the utilized VR application.

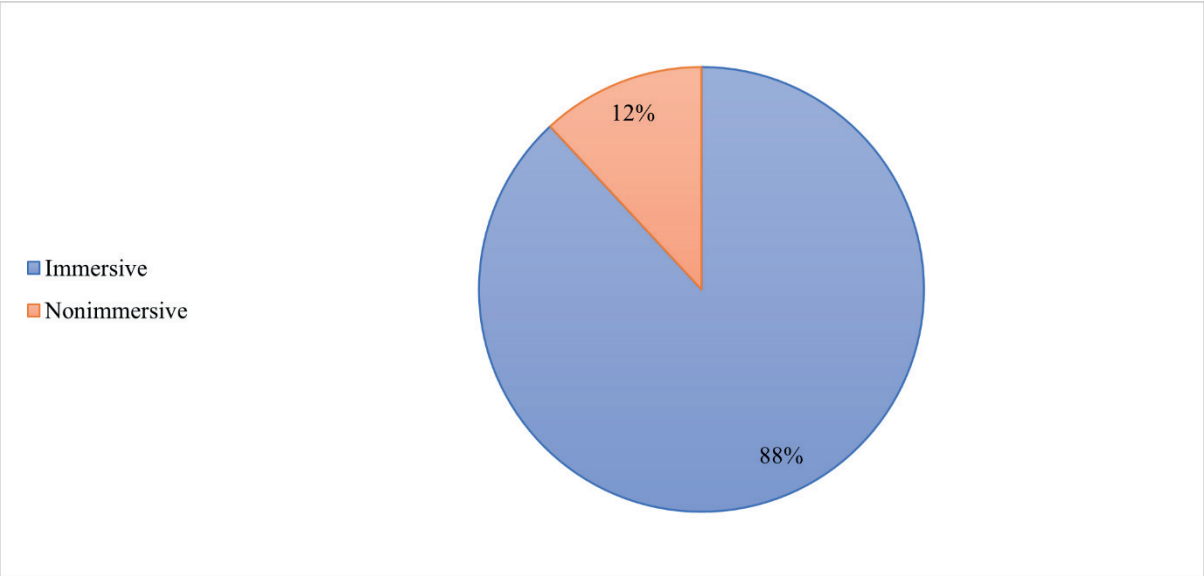

Figure 8. Distribution of VR research by VR type

Figure 9 presents the distribution of VR technologies utilized in research. Predominantly, the most favored technology is HMDs (n = 36). Among these, 20 studies exclusively utilized HMDs, while 16 studies incorporated a joystick in conjunction with HMDs. Additionally, other technologies, such as desktop (n=4), game console (n=1), and mobile phone (n=1), were less frequently employed. Notably, in one study, specific information regarding the utilized VR technology was not available.

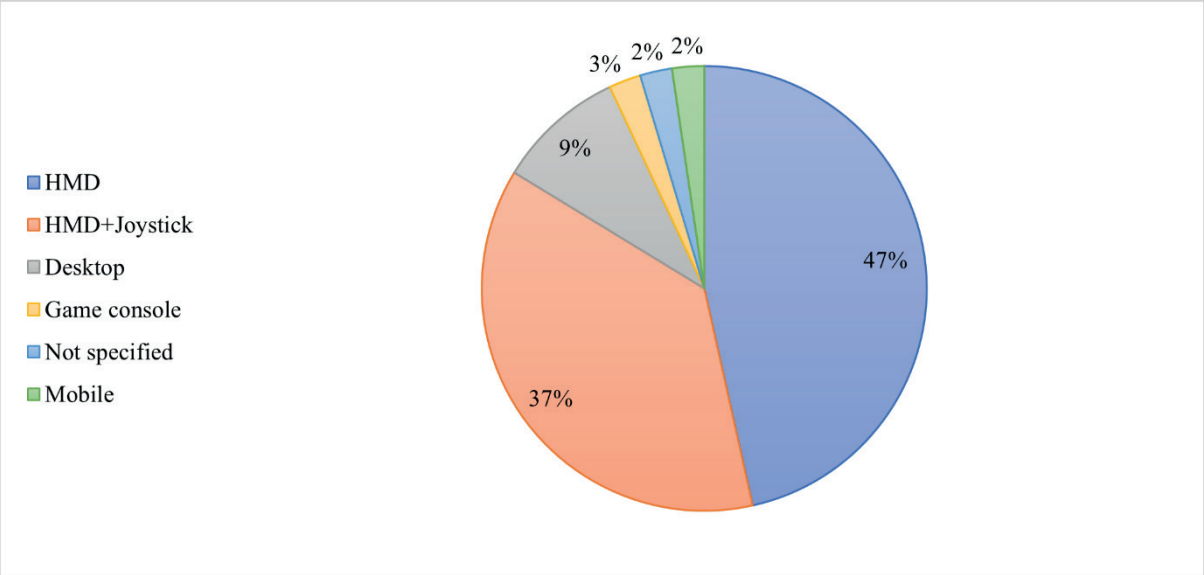

Figure 9. Distribution of VR research by VR technology

Figure 10 illustrates the distribution of learning domains targeted for enhancement through VR utilization within the studies included in the SLR. Notably, the predominant focus lies on improving declarative knowledge (n = 18). For instance, Tugtekin's research (2019) exemplifies this, employing VR applications to elucidate the lightning formation process, enabling participants to comprehend its stages. Following closely, problem-solving skills (n=10) emerge as the second most addressed domain. For instance, Dogan (2021) aimed to simulate scenarios where participants, acting as pharmacists, plan treatment processes based on virtual patient responses, prompting analysis and solution provision. Procedural knowledge (n=6) stands as another targeted area, as demonstrated in Tacgin's research (2017), where participants engage in procedures related to preparing surgical sets used in operating rooms. However, relatively fewer studies focus on learning a language (n=5), behavioral impacts (n=5), and soft skills (n=3). For instance, Dalak (2022) delved into the behavioral implications, examining participants' self-regulation behaviors, while Kocbug (2018) explored VR's impact on word learning, representing learning a language. Additionally, Akbiyik (2020) investigated VR's efficacy in teaching communication initiation and maintenance for individuals with autism spectrum disorder (ASD), contributing to the domain of soft skills learning.

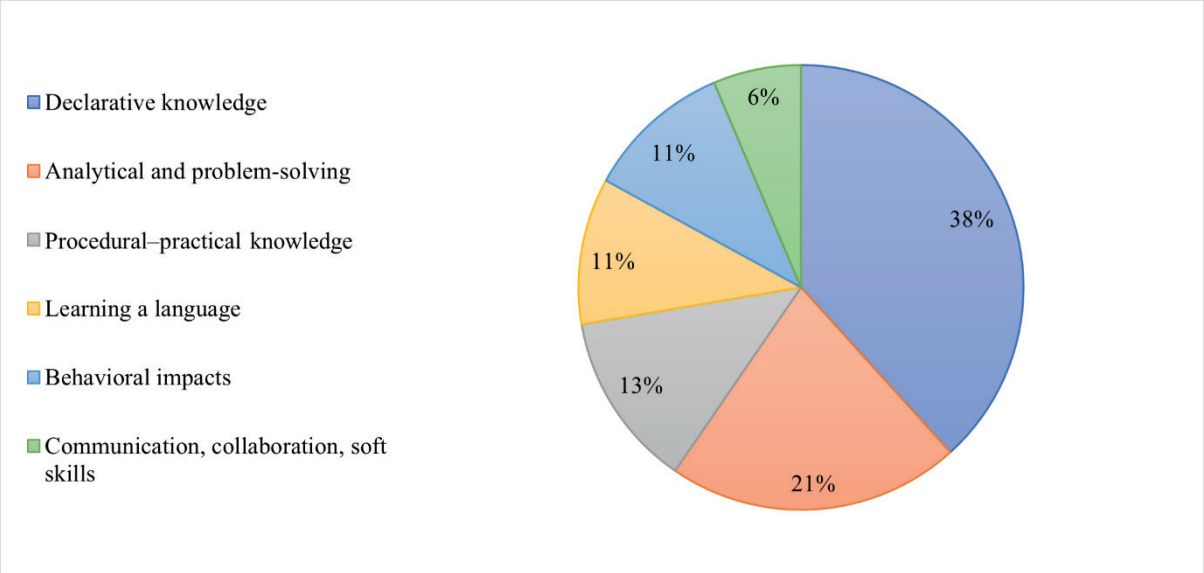

Figure 10. Distribution of VR research by learning domain

Figure 11 portrays the distribution of learning-teaching theories forming the basis of VR research in the education domain. Notably, in constructing the theoretical frameworks, the most favored theory observed was constructivism (n=11). Following this, there were three studies each grounded in experiential learning and multimedia learning, along with two studies rooted in distance education theories. Moreover, individual studies were designed based on discrete trial teaching, behavioral skills training, flipped learning, game-based learning, self-regulated learning, scenario-based learning, and task-based language teaching. A noteworthy finding from this analysis is the absence of any explicitly mentioned learning-teaching theory in 17 studies within VR research frameworks.

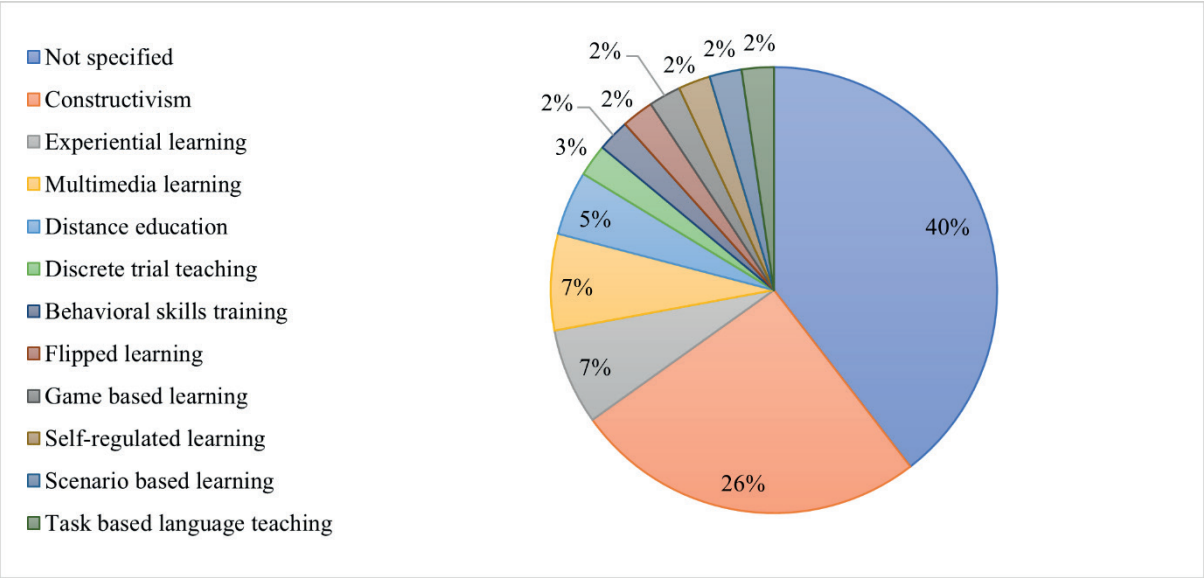

Figure 11. Distribution of VR research according to learning theory

Figure 12 illustrates the distribution of design elements incorporated into VR applications within the research. Notably, the most prevalent design elements observed include realistic experience (n=33), passive observation (n=32), moving around (n=28), and interaction with the virtual environment (n=24). Following these, feedback was present in 14 studies, while informing within the virtual environment and enabling meaningful choices were apparent in 12 and 11 studies, respectively. Conversely, less frequently used design elements encompassed assembling objects (n=4), screen sharing (n=4), knowledge testing (n=11), virtual rewards (n=3), interaction with other users (n=2), and user-generated content (n=1).

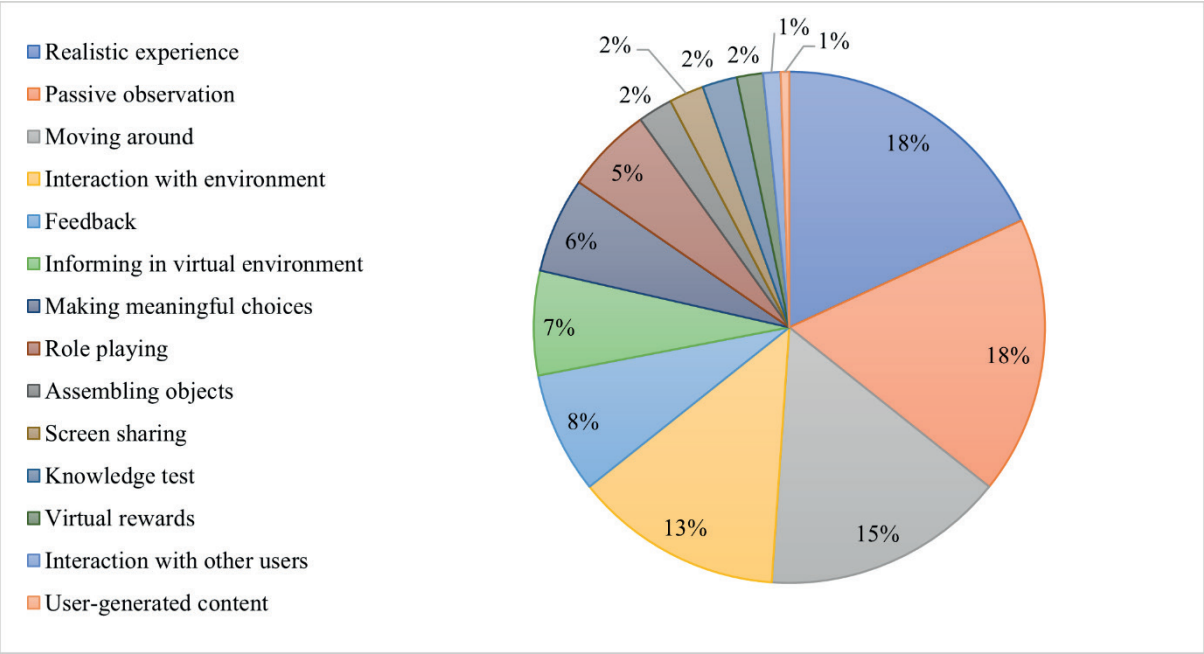

Figure 12. Distribution of VR research by design element

Figure 13, depicted as a bubble chart, illustrates the relationship between the departmental affiliation and research designs employed in the studies. Notably, within the instructional/educational technology department, prevalent research designs encompass qualitative research (n=7), experimental research (n=6),

and design and development research (n=3). Science education, educational science, primary school teaching, physical education, and sports teaching departments predominantly employed experimental and qualitative research methodologies. Conversely, the special education department, by its nature, primarily utilized single-subject research (n=1) alongside experimental and qualitative research. Studies within mathematics education were predominantly conducted using design and development and qualitative research. Conversely, departments such as graphic education, English language teaching, Turkish teaching, and management information systems relied solely on experimental research. Notably, in social sciences teaching studies, qualitative research emerged as the preferred methodology. A noteworthy observation is the substantial preference for design and development research observed primarily within the instructional/educational technology department.

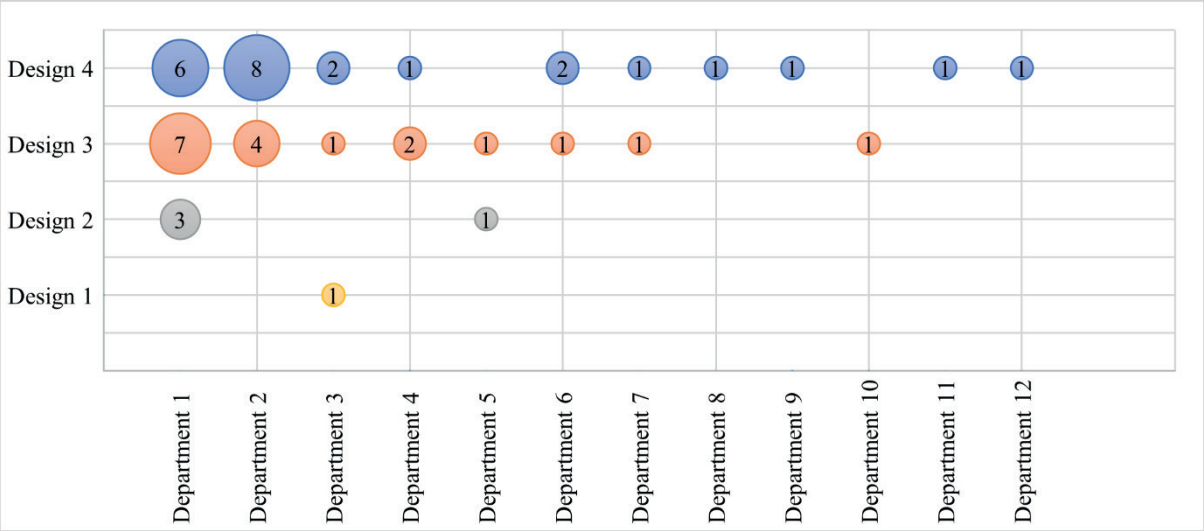

Figure 13. Research design relationship with the department where VR research is conducted

Figure 14 delineates the relationship between the departmental focus in VR studies and the intended learning domains. Notably, studies within the instructional/educational technology department encompassed a wide spectrum, targeting multiple domains such as behavioral impacts, learning a language, declarative knowledge, procedural knowledge, soft skills, and problem-solving. However, within science education, the emphasis primarily lay on declarative knowledge despite its applied nature. Special education studies were directed towards soft skills, procedural knowledge, and declarative knowledge. Meanwhile, research conducted in educational science and primary school teaching departments predominantly centered around the problem-solving domain. In the mathematics education department, studies aimed at problem-solving and behavioral impacts. Notably, studies in physical education and sports teaching primarily concentrated on procedural knowledge. Conversely, departments including graphic education, social sciences teaching, and management information systems primarily targeted the declarative knowledge domain. Lastly, studies within the English language teaching and Turkish teaching departments inherently focused on the domain of learning a language.

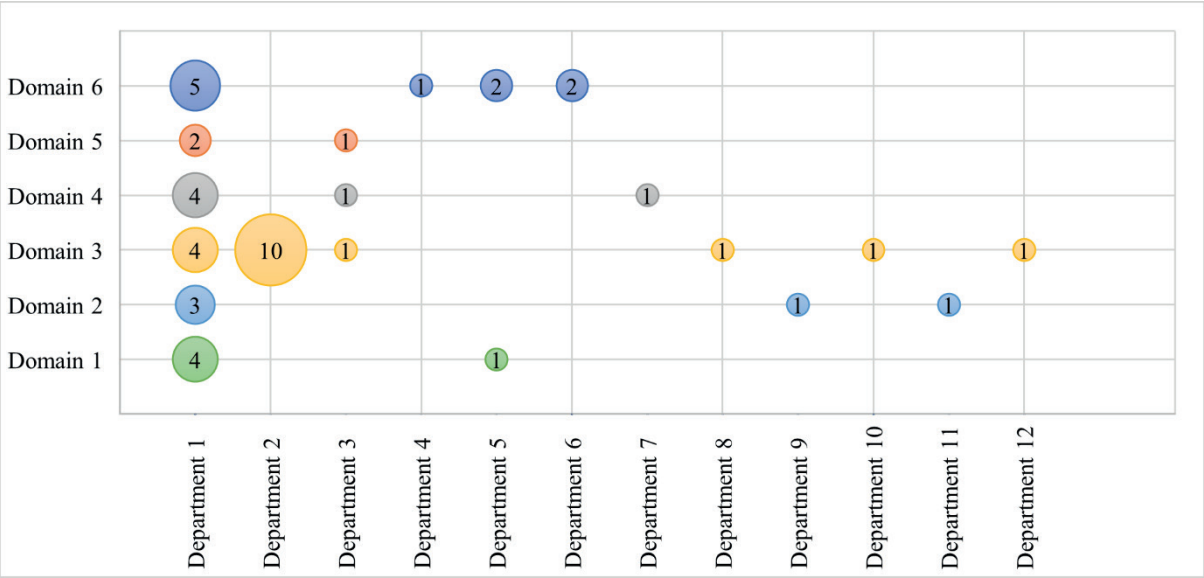

Figure 14. The relationship between the field of VR research and the learning domain

Figure 15, represented as a bubble chart, outlines the relationship between departments and the underlying learning theories in research. Notably, studies within the fields of graphic education, English language teaching, social science teaching, and Turkish teaching lack a specified theoretical basis. In the management information systems department, the sole study is grounded in experiential learning theory. Meanwhile, the study within the Physical education and sports teaching department is based on constructivism. Primary school teaching research primarily leans towards constructivism and self-regulated learning, while mathematics education emphasizes constructivism and game-based learning theories. Within the educational science department, research aligns with experiential learning and distance education theories. In the special education department, the focus is on discrete trial teaching theories. In science education, although constructivism, distance education, and flipped learning were observed in some studies, three studies lacked a specified theory. While most studies in the instructional/educational technology department do not specify a theoretical basis, a few are based on constructivism, experiential learning, multimedia learning, behavioral skills training, game-based learning, and task-based language teaching theories.

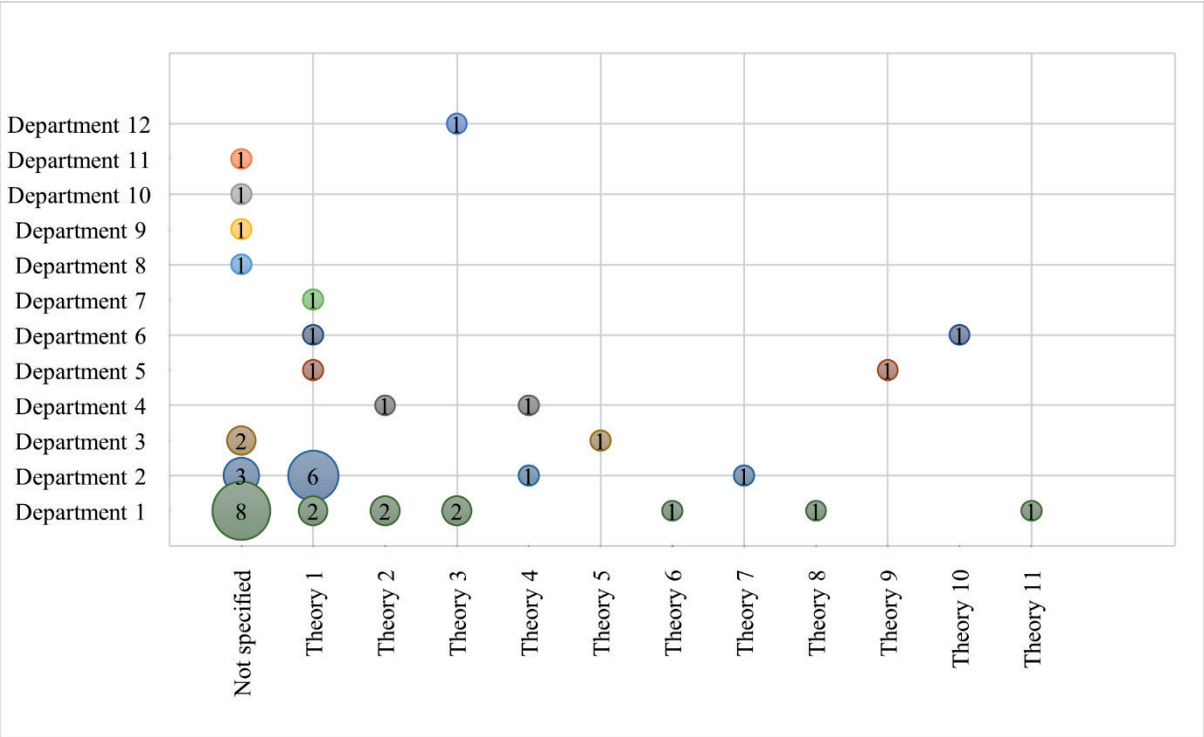

Figure 15. Relationship between the department where VR research is carried out and learning-teaching theory

Figure 16, depicted as a bubble chart, illustrates the relationship between design elements and the type of VR employed in research. Notably, common design elements observed in both immersive and nonimmersive VR applications encompass realistic experience, passive observation, movement within the environment, interaction with the environment, interaction with other users, and screen sharing. However, immersive VR applications include additional prevalent design elements such as role-playing (n=10), informing within the virtual environment (n=12), feedback (n=14), and making meaningful choices (n=11). Conversely, less frequently used design elements within immersive VR applications encompass user-generated content (n=1), knowledge testing (n=4), and virtual rewards (n=3).

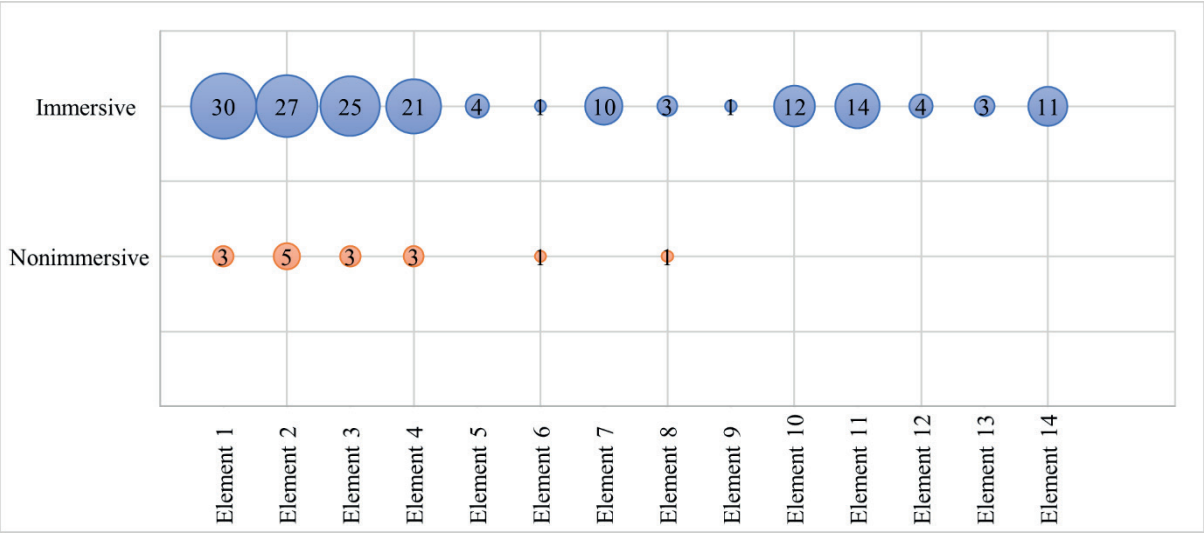

Figure 16. Relationship between design element and VR type in VR research

Figure 17, displayed as a bubble chart, illustrates the relationship between design elements and learning domains. Notably, in research focused on the problem-solving domain, prevalent design elements include interaction with the environment (n=10), movement within the environment (n=8), feedback mechanisms (n=8), and enabling meaningful choices (n=8). Conversely, elements such as interaction with other users (n=1), user-generated content (n=1), and knowledge testing (n=1) are less frequently utilized within this domain. For studies targeting soft skills, knowledge testing and virtual rewards elements have not been used, while other design elements have limited application, appearing once or twice.

In research addressing procedural knowledge, the frequently employed design elements encompass realistic experiences (n=6), movement within the environment (n=5), interaction with the environment (n=5), and information presentation within the virtual setting (n=5). Notably, interaction with other users has not been utilized within this domain. For studies focusing on declarative knowledge, commonly utilized design elements include passive observation, realistic experiences, and interaction with the environment. Conversely, elements such as assembling objects, interaction with other users, role-playing, user-generated content, virtual rewards, and meaningful choices have not been encountered within this domain.

In VR applications aimed at learning a language, prevalent elements involve movement within the environment, realistic experiences, passive observation, interaction with the environment, knowledge testing, role-playing, information presentation within the virtual setting, and meaningful choices. Lastly, VR applications directed at behavioral impacts commonly incorporate realistic experiences, movement within the environment, and interaction with other users, whereas elements like knowledge testing and virtual rewards are absent within this domain.

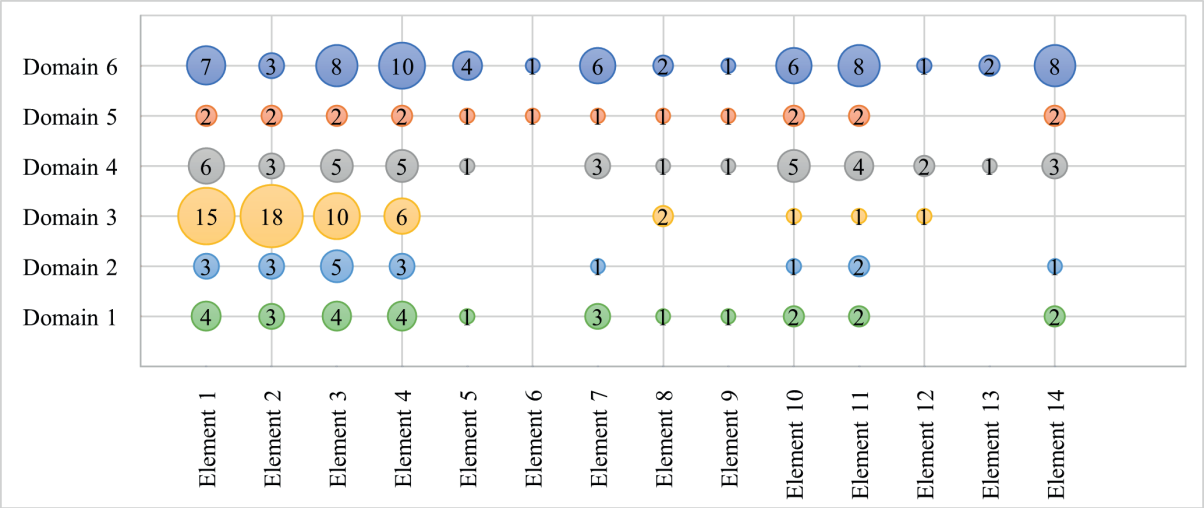

Figure 17. Relationship between the design element and the learning space in VR research

DISCUSSION AND RECOMMENDATIONS

The fields of instructional/educational technology and science education emerged as the most active departments conducting VR research, potentially owing to their inclination toward immersive learning environments. However, despite this inclination, VR applications have proven effective across various domains, showcasing positive impacts on learning outcomes (Bailenson et al., 2008; Dogan & Sahin, 2023; Koivisto et al., 2018; Merchant et al., 2014). A significant challenge in adopting VR lies in the technical complexity inherent in its implementation, as highlighted by Maples-Keller et al. (2017). Nonetheless, Dogan and Sahin (2023) demonstrated that this obstacle could be overcome by developing user-friendly interfaces in VR environment design. Such advancements could democratize the utilization of VR applications, enabling educational research across all academic departments.

The progression of VR research has shown a steady increase since 2011, particularly surging from 2018 onward. This trend aligns with findings from Radianti et al. (2020) and Suh and Prophet (2018). Moreover, the Gartner hype cycle indicated that VR transitioned into the slope of enlightenment phase in 2016,

signifying widespread acknowledgment of its benefits. Consequently, the increased frequency of VR becoming a focal point in educational research post-2018 appears consistent with the growing recognition of VR's potential benefits.

Upon methodological scrutiny of VR research, it's evident that experimental research stands as the most frequently employed method, focusing notably on examining VR's impact on various facets of the learning process. The substantial use of qualitative research aligns with prior findings by Suh and Prophet (2018). However, it's noteworthy that design and development research are markedly underutilized. This contrasts with the prevalence of design-oriented studies in VR literature, as highlighted by Radianti et al. (2020). Incorporating design-oriented research is crucial, considering that VR applications necessitate thorough design and development stages. The absence of such studies within research frameworks limits guidance for future endeavors, urging a shift towards emphasizing design-oriented research in VR applications. Upon exploring the correlation between research design and department, a notable observation emerged: the prevalent preference for design and development research within the department of instructional/educational technology. This inclination can be attributed to the comprehensive training instructional technologists undergo, specifically in the design and development of instructional design and materials. Hence, leveraging the expertise of professionals in this department becomes imperative when undertaking research involving VR applications.

An overwhelming majority (91%) of VR application participants comprise K12 and higher education students. Nonetheless, the evolving landscape of education systems from closed to open systems includes numerous new stakeholders (Anderson et al., 2001). Encouraging the involvement of stakeholders like parents, teachers, community leaders, and non-governmental organizations can significantly enhance the system's success (Khadija, 2022). Hence, it's imperative to expand participant groups in VR research to encompass managers, policymakers, teachers, experts, and others involved in educational realms. Our findings emphasize the predominant use of test, scale, and interview tools, indicating a focus on variables like achievement, affective skills, and opinions. This prevalence aligns with the frequent use of experimental and qualitative research methodologies. Correspondingly, the preference for data analysis methods appears connected to research design, with parametric tests and content analysis being predominantly employed. These trends corroborate with prior SLR results (Radianti et al., 2020).

The research indicates a significant preference for immersive VR, constituting almost 90% of VR research endeavors, prominently utilizing technologies such as HMD and HMD with joystick. These findings align consistently with prior studies (Radianti et al., 2020; Suh and Prophet, 2018), reinforcing the convergence of our research outcomes with existing SLR trends.

The outcomes predominantly highlight efforts aimed at enhancing declarative knowledge through VR applications. Declarative knowledge forms the fundamental basis for verbal knowledge and intellectual skills. Additionally, problem-solving and procedural knowledge emerge as other frequently targeted domains in VR research. This tendency aligns logically with VR's potential for practical application. Notably, Radianti et al. (2020) observed a similar trend, albeit ranking procedural knowledge as the foremost domain. Examining the association between these learning areas and the departments conducting research revealed that instructional/educational technology studies encompassed research across all domains. This phenomenon can be attributed to the interdisciplinary nature of instructional technology. Conversely, although science education primarily focuses on applied aspects, its studies predominantly aim at declarative knowledge. Consequently, it's advisable for this field to explore studies on procedural knowledge and problem-solving.

Our study unveils a significant trend wherein nearly half of the VR studies lack a clear theoretical foundation, with Constructivism being the most frequently cited learning theory. This finding is expected, given the strong compatibility between VR utilization and the constructivist paradigm. Mikropoulos and Natsis (2011) highlighted a similar trend in their review of VR in education, observing that few studies were grounded in theoretical or pedagogical frameworks, with most aligning with constructivism. Similarly, Radianti et al. (2020) reported that 68% of studies didn't reference any theoretical foundations. Notably, no mention of learning-teaching theories was observed in studies within the departments of graphic education, English language teaching, social science teaching, and Turkish teaching, suggesting a need for theoretical foundation training across disciplines, particularly in these areas.

Examining the design elements of VR applications, we note the frequent usage of elements like realistic experience, passive observation, moving around, and interaction with the environment. This observation echoes findings by Radianti et al. (2020) and aligns with Suh and Prophet's (2018) mention of intense applications involving immersion, presence, and interactivity. However, when we investigate the relationship between design elements and VR type, we find that while many studies claim an immersive experience, elements such as assembling objects, screen sharing, virtual rewards, interaction with other users, and user-generated content are scarcely incorporated. This discrepancy underscores the need for a deeper exploration into the concept of immersion.

Upon analyzing the design elements in VR applications and their correlation with the learning domains targeted for development, several distinct associations emerge. Elements such as interaction with the environment, moving around, feedback, and making meaningful choices are prominently featured in applications aimed at enhancing problem-solving skills. Given that problem-solving inherently involves interactivity, feedback mechanisms, and decision-making, this alignment is quite logical. Interestingly, elements like knowledge testing and virtual rewards are consistently absent in applications focusing on soft skills. This absence might be attributed to the emphasis on communication and collaboration in this domain. Notably, applications aiming to enhance procedural knowledge frequently employ elements such as realism, interactivity, and information dissemination within the virtual environment. These elements seem tailored to simulate realistic experiences that aid in procedural knowledge acquisition.

Declarative knowledge applications often prioritize passive observation, presenting users with immersive oral presentations resembling traditional learning environments. Conversely, applications geared towards learning a language frequently incorporate the moving around element, encouraging users to navigate the virtual environment to learn object names. In the domain of behavioral impacts, realistic experience, moving around, and interaction with other users emerge as preferred elements. This domain, focused on inducing behavioral change, notably highlights interaction with others, a feature standing out for the first time in this area. Previous studies by Wohlgenannt et al. (2019) also indicated a preference for exploration elements in declarative knowledge, instruction elements in procedural knowledge, and realistic environments for problem-solving and collaboration skills. Our research thus contributes additional insights to the existing literature, suggesting the need for further investigations into the specific design elements that significantly contribute to the development of distinct learning domains.

LIMITATIONS

Our study specifically focused on VR applications within educational processes, overlooking the broader spectrum of VR's extensive applications. VR's reach extends across diverse domains, spanning health, engineering, social sciences, and advertising, where VR applications might have attained varying levels of maturity. Consequently, our research outcomes are confined solely to the educational domain, limiting insights into advancements and trends present in other sectors leveraging VR technology.

Additionally, our SLR primarily encompassed postgraduate thesis studies conducted in a Eurasian country (Table 6), aiming for an extensive scope by examining VR studies without temporal restrictions. However, this review's limitations are evident in its exclusion of publications like articles and papers, which might offer deeper insights and diverse perspectives on VR applications beyond the confines of theses.

Table 6. Studies included in SLR

	Author	Title
1	Abdusselam (2022)	The effect of augmented and virtual reality technologies on using light microscope in science teaching
2	Akbiyik (2020)	Effectiveness of virtual reality technology on teaching communication initiating and maintenance skills to students with autism spectrum disorder
3	Akman (2019)	The investigation of the effects of a virtual reality application developed for fractions in the mathematics lessons of elementary school considering some different variables
4	Albayrak (2015)	The impact of Kinect usable 3d virtual reality applications on young learners' vocabulary development in foreign languages vocabulary learning

5	Arici (2013)	A study on 3D-virtual reality in science education programs: "Solar system and beyond: Space puzzle" unit sample
6	Bilen (2023)	The effect of virtual reality based virtual museum design application on student achievement in science education
7	Bilgin (2018)	The evaluation of different technology supported learning environments for data sub-learning field in secondary mathematics curriculum
8	Bozdemir (2022)	The effect of immersive virtual reality use on listening skill in foreign language education
9	Ceken (2023)	Examination of multimedia learning principles in augmented reality and virtual reality learning environments
10	Coruh (2011)	Assessment of the effectiveness of virtual reality applications in art history course as a learning model (An example of Erciyes University architecture & fine arts faculties)
11	Dagdalan (2019)	The effects of virtual reality supported science education on students' cognitive levels, meta cognitive awareness and attitudes toward virtual reality
12	Dalak (2022)	Mathematics teachers' self-regulated learning behaviors in an immersive virtual environment
13	Demir (2018)	Investigation of students' views on the use of virtual reality in algorithm teaching in the context of learning styles
14	Denizalp (2022)	Investigation of the effects of a virtual reality application developed for area measurement and geometric objects in mathematics lessons considering some different variables
15	Dogan (2021)	Design and development of virtual reality environments in Pharmacy education
16	Dogdu (2023)	An implementation intended to flipped classroom model supported by virtual reality: Example of solar and beyond unit
17	Durukan (2018)	Investigating the effects of virtual reality enriched learning environment on pre-service science teachers
18	Gokoglu (2019)	The impact of virtual reality based learning environment on the development of behavioral skills towards fire safety
19	Gul (2016)	Exploring the use of 3D virtual worlds for psychoeducational groups: A multiple case study
20	Guler (2021)	Mobile based virtual reality application development study for visuospatial skills of dyslexic individuals
21	Gunduz (2022)	The effect of virtual reality assisted task-based language teaching approach on graduate students
22	Kalkan (2020)	Examining the efficiency of virtual reality technology in basic technical skills training: Table tennis case study
23	Karadayi (2022)	A case study on implementing experiential learning supported with virtual reality technology in teacher education
24	Kocbug (2018)	The effectiveness of virtual reality tools on vocabulary learning and retention
25	Kurt (2022)	The effect of virtually reality practice on mathematic success of students with learning disabilities
26	Kurtca (2021)	Effectiveness of virtual reality technology in teaching pedestrian skills to children with intellectual disabilities
27	Mete (2021)	Design and development research: "Hezarfen VR" educational virtual reality game
28	Metin (2023)	The use of virtual reality applications in social studies teaching: seben rock houses and fossil forest examples
29	Ozer (2023)	A case study on the use of virtual reality application in primary school science course
30	Ozonur (2013)	The design of second life applications as virtual world and examining the effects of these applications on the learning of the students attending internetbased distance education in terms of different variables
31	Sagdic (2019)	A comparison of discrete trial teaching and virtual reality glasses teaching effectiveness in teaching facial expressions to students with autism spectrum disorder
32	Saricam (2019)	Investigation of the effect of virtual reality applications on teaching circulatory system concepts in science lesson
33	Sarioglu (2019)	The effect of using virtual reality in 6th grade science course the cell topic on students' academic achievements and attitudes towards the course
34	Tacgin (2017)	Development and evaluation of a virtual reality simulation to teach surgical sets used in the operating room

35	Tarhan (2020)	The effect of virtual reality tools on vocabulary learning in teaching Turkish as a foreign language and its efficiency in retention
36	Tay (2020)	Evaluation of the effects of the virtual campus tour application designed according to panoramic based virtual reality
37	Tepe (2019)	Investigating the effects of virtual reality environments developed for head-mounted display on learning and presence
38	Topuz (2018)	The comparison of virtual reality and desktop three-dimensional materials in anatomy teaching in terms of academic performance and cognitive load
39	Tugtekin (2019)	Effect of reducing extraneous processing principles on cognitive load and achievement in augmented reality and virtual reality environments in multimedia learning
40	Urhan (2019)	Investigation of the effect of virtual reality applications for science education
41	Unal (2022)	Virtual museum implementation on biology issues: Its reflection to science teachers
42	Yesiltas (2019)	The effect of guide materials based on animation and virtual reality on some learning products; example of circulatory system
43	Yilmaz (2023)	Examination of technology-supported laboratory applications in terms of different variables

Our research primarily emphasizes the interrelation between design elements, learning domains, learning-teaching theories, and research designs within VR studies. Consequently, aspects like the advantages and disadvantages of integrating VR in educational settings were deliberately omitted from our study's scope. Essentially, our research is confined to exploring and analyzing the specific elements inherent to VR applications within educational contexts.

CONCLUSION

The aim of this research is to delineate the prevailing trends in VR applications within educational contexts and to explore the interconnectedness among learning-teaching theories, learning domains, design elements, VR types, and the departments conducting such research. The findings indicate a notable concentration of VR research within technology-related departments. The predominant approach in this domain involves experimental examinations of diverse variables within VR learning environments, yet there's a scarcity of design-oriented studies. Considering the current characterization of VR research as the 'Wild West' with a lack of established guidelines (Birckhead et al., 2019), there's a pressing need for research that elucidates the design and development processes comprehensively. Furthermore, a striking revelation is the absence of a solid theoretical framework in the majority of studies. Given the pivotal role of learning-teaching theories in guiding these processes, their absence might impede the broader integration of VR in educational settings. In exploring design elements, the prominence of realistic experience, passive observation, moving around, and interaction with the environment is evident. Recognizing the potential impact of diverse elements in enhancing realism, it's apparent that aligning specific elements with distinct learning domains can elevate the immersive quality of VR experiences.

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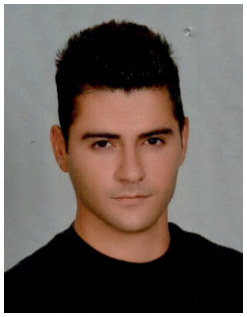

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LEARNING LIFE SKILLS THROUGH MULTICULTURAL EXCHANGE: AN EXAMINATION OF PROSPECTIVE ENGLISH LANGUAGE TEACHERS' EXPERIENCES

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ABSTRACT

The student exchange programs are venues for learning opportunities by offering multicultural contexts. This study reports on the experiences of ten prospective English language teachers in a virtual student exchange program to investigate likely skill development in a multicultural and open and distance learning setting. This descriptive study used the qualitative method. The textual data were elicited through eighty reflective essays written by the participants. Virtual classroom observations and WhatsApp chat data ensured data triangulation. The results revealed the themes as developed learning and life skills and enhanced internal gains. It was found that internal outcomes, such as self-confidence, empathy, and self-reliance, were enhanced rather than external gains. One of the limitations of this study was the brevity of the exchange program, which lasted only eight days. Additionally, the current study is a small-scale study, which limits the generalizability of the results. Last but not least, only two participants placed in the researcher's class were observed. The study poses a few implications for education policymakers, curriculum developers, and teachers. In light of the results, it is posed that adding a multicultural aspect to the teacher training curriculum is imperative for teacher empowerment. Though the literature on student exchange reports findings on the gains and challenges, there is a scarcity of studies delving into what skills students develop and how with vivid examples. In this respect, this study adds to the relevant literature.

Keywords: Life skills, student exchange, higher education, e-learning, multicultural education, 21st century life skills, virtual classrooms.

INTRODUCTION

Due to globalization, education has undergone a substantial change. This change has brought many perspectives into educational contexts. One of these changes is that the classes are no longer mono-national and hence monocultural (Richter, 2022). In the present-day world, students with differing mother tongues and cultures receive education together in multicultural contexts. Consequently, the need for educating students to be global citizens has emerged. Higher education institutions have felt this need to integrate a global perspective into tertiary education long before other types of schools since most serve an international and multicultural community of university students (Oral & Lund, 2022; Ghani et al, 2022). Brodin (2010) argues that adopting a multicultural perspective is vital in teacher education programs. To prepare them for multicultural classrooms, they need to be provided with an international experience by linking them to other countries. Student exchange programs play a significant role in the development of multicultural awareness. As well as raising awareness, such programs are also effective in increasing knowledge about other cultures, cultivating empathy, and developing respect for others (Eren, 2023; Hossain et al, 2022).

The interplay between multicultural contexts and open and distance learning (ODL) is intricate and multifaceted (KIlavuz, 2023; Aphek, 2001). Open and distance education, characterized by its flexibility and lack of dependence on physical classroom settings, holds the potential to transcend geographical boundaries and accommodate a diverse array of learners from various cultural backgrounds. In multicultural settings, ODL becomes a potent avenue for addressing educational barriers tied to cultural disparities or geographic remoteness (Bakay, 2023). An essential facet of this relationship involves the incorporation of cultural sensitivity and inclusivity within ODL frameworks for skills and capacity development (Dlamini & Mulaudzi, 2016). Customizing learning materials to reflect diverse cultural perspectives, languages, and historical contexts is paramount. The design of ODL programs should prioritize fostering a sense of inclusivity and respect for diversity, ensuring that content, materials, and instructional methods resonate with learners from different cultural backgrounds (Miglani et al., 2018).

Eastmond (2004) acknowledges that working with international students poses opportunities and challenges for 21st-century academia for teachers (p. 1). Eastmond (2004) contends that students can benefit from experiences, shared knowledge, and personal relationships, which have the potential to transform their lifestyles. Therefore, it is imperative to conduct empirical studies on the issue. First, it must be noted that research in global education is underdeveloped (Lopez-Martin et al, 2023; Scheunpflug and Asbrand, 2006). Of course, contacting other cultures poses many challenges and opportunities, which calls for a need to

provide deeper insights into the issue. It is hypothesized that language barriers will be the main issue. Thus, to overcome this challenge, the study participants consisted of prospective English language teachers, which has helped to overcome or minimize such challenges. The study expected that students would develop skills to cope with the challenges imposed by the multicultural context, which was new to them, and more excellent cultural knowledge would be gained. Since there is only a handful of studies on the likely contributions of student exchange programs on skill development, this study fills a void in the relevant literature.

Virtual student exchange programs create learning opportunities by providing multicultural contexts. This study aims to examine the experiences of a prospective English language teacher in a virtual student exchange program in order to explore possible skill development in a multicultural environment. Studies in the literature reveal that students' perceptions of virtual student exchange programs and intercultural competencies contribute to the development of language skills, critical digital literacy, and interdisciplinary learning (EVOLVE, 2020; Doery et al., 2004; Sernbo et al., 2023).

LITERATURE REIVEW

Global learning encompasses "responsibility, citizenship, good health, personal achievement, participation or making a living" (Majewska, 2023; Standish, 2014). Standish (2014) argues that the term 'global' is used in an inclusive sense, encompassing international education, sustainable development education, global citizenship education, twenty-first-century skills, development education, human rights education, and other such 'big concepts.' Inclusion has been an essential feature of education since most schools especially higher education institutions, serve a multinational and hence multicultural community. More recently, these institutions have focused on the importance of globalization and global education curriculum to develop "knowledge, skills, attitudes, and experiences necessary either to compete successfully in the global marketplace or to work toward finding and implementing solutions to problems of global significance" (Mutiani et al, 2022; Lewin, 2009). Globalization in education entails developing globally minded attitudes, such as adopting a world perspective beneficial for every party (Holmarsdottir et al., 2023; Che et al., 2009, p. 101).

Multiculturalism entails accepting differences based on tolerance, regardless of the cultural and belonging claims of foreigners and differences of a state or country (Doytcheva, 2016). Awareness of and respect for people from different cultures, ethnic origins, identities, and minorities (Yanik, 2012) ensure people live together in equality and peace (Parekh, 2002). Multicultural education is the adaptation of equal and fair multiculturalism to education, which emerges as the opposite of monocultural education (Mareye, 2023). Today, it is seen that the number of multicultural education studies is increasing day by day in educational research. Research shows that one of the significant challenges of multicultural education is that some societies do not exhibit positive behaviors towards different cultural communities (Cirik, 2008). The reasons for this negative attitude are identified as the increasing racism in developed continents, such as Europe and America, in recent years, migration, and the decline in the welfare level of societies. In this respect, multicultural education has emerged to find solutions for these challenges (Bell, 2023; Matafora et al., 2023).

Multicultural education reveals the similarities between cultures and examines the differences between cultures. The primary purpose of multicultural education is to show tolerance to other cultures, prevent racism, increase awareness of different cultures, and get to know the universe in terms of various cultures (Islam, 2023; Noddings, 2016). Banks (2013) emphasizes that the purpose of multicultural education is to support people to see themselves from the perspective of other cultures to get to know themselves better, respect different cultures learn about various ethnic groups and have knowledge and skills.

Communication and interaction are pivotal components in ODL, gaining even greater significance in multicultural environments. Platforms supporting ODL need to facilitate diverse forms of communication, considering linguistic diversity and cultural nuances (Ugurhan et al., 2020). Encouraging interaction and collaboration among students from varied backgrounds enhances the overall learning experience. Cultural competence in educators is imperative, necessitating an understanding of the cultural backgrounds of learners and the ability to navigate cultural differences effectively (Karacabey et al., 2019). Professional development programs for educators should incorporate training on multicultural competence (Kok, 2010).

Student exchange projects and programs benefit participants in terms of personal growth. Gray et al. (2002) assert that an international educational experience in a multicultural context provided gains in self-confidence, maturity, and empathy. Being a part of a student exchange led to enhanced intercultural learning, global awareness, self-development, language acquisition, and many other positive long-term impacts (Giedt et al., 2015). Similarly, Sindt (2007) found that American college students reported significant internal gains. They admitted to being more mature, autonomous, and independent. Research delving into educational experiences in international contexts shows beneficial results in terms of language proficiency (Miranda & Wahyudin, 2023; DuFon & Churchill, 2006; Engle & Engle, 2004), intercultural understanding (Engle & Engle, 2004; Ingraham & Peterson, 2004; Zielinski, 2007; Lou & Bosley, 2023), cultural exchange (Fitzpatrick et al., 2011; Hiebert, 2005) and disciplinary knowledge (Sutton and Rubin, 2004; Vande Berg et al., 2004). The aim of these educational experiences in international contexts was 'opening minds to the world and facilitating mutual understanding and global connection' (Kim, 2015; Suryanto et al, 2022).

The assessment strategies employed in ODL within multicultural contexts must be culturally fair and devoid of bias (Tuc & Karadag, 2023). This ensures equitable evaluation for students with diverse cultural backgrounds. Institutional policies and support structures play a crucial role, addressing the unique needs of a diverse student body in ODL programs (Acar Ciftci, 2019). This encompasses provisions for language support, cultural integration, and assistance with technology access. In essence, the dynamic relationship between multicultural contexts and ODL is grounded in issues of access, inclusivity, cultural sensitivity, and effective communication (Bayyurt et al., 2019). Through thoughtful approaches, ODL emerges as a powerful means to deliver quality education globally while fostering a truly inclusive and globalized learning environment.

Brodin (2010) conducted a study to evaluate an exchange project to elicit undergraduate students' views from the United Kingdom, Sweden, and Finland. The participants worked with children, parents, and communities in a multicultural context. The results revealed the positive aspects to be 'strong teacher support, opportunities to make new friends for life, to experience a new culture, and to learn about a new country' (p. 9) as well as 'increased personal benefits like gaining independence and opportunities to increase self-esteem'. On the other hand, the challenges were identified as having mixed classes, 'quicker installation of network access in the student rooms, longer periods of exchange and lack of coordination between their home schools and the other schools in Europe'(p. 9). Brodin (2010) also found that the exchange project contributed to academic development by providing 'an understanding of new perspectives on teaching methods and ways of learning, awareness of the sociocultural differences, getting an opportunity to reflect and discuss with classmates'.

CONTEXT OF THE STUDY

In the 1990s when the higher education institutions were first founded in north Cyprus, the classes were mostly mononational. A great majority of the students were either Turkish or Turkish Cypriot. Now the higher education institutions on the island boast attracting international students from 118 countries worldwide, which illustrates the rapid globalization on the island in general and tertiary education in north Cyprus in particular. Owing to globalization in tertiary education, a multicultural perspective should be brought into teacher education. Except for some elective courses like Culture and Language and World English and Culture, the English language teaching curriculum fails to have courses on multicultural education. In his respect, ways need to be searched to prepare prospective English language teachers for multicultural classrooms. Their future classrooms will definitely be multicultural because most of them will be teaching either in Turkiye or in north Cyprus and both countries attract immigrants. One strategy to prepare them for the multicultural classroom is to provide them with international experience through exchange programs. They are expected to broaden their perceptions of the world (Nada & Legutko, 2022; David, 2007; Silberfeld, 2006) and to develop essential skills to contribute to the activities during these programs.

The global exchange program organized by St. Aloysius College in Jabalpur took place between 4-11 March 2023. The goal of the program was to engage participants in both personal and global experiences that will enable them to get to know other cultures and acquire the knowledge, skills, and attitudes necessary to

thrive in a universal multiethnic civilization. The main theme was identified as Language and Culture by the Global Understanding Program. The aim of the Global Understanding Program initiative is to "encourage the formation of new interdisciplinary partnerships, with a particular focus on exploration that spans both disciplinary and geographical boundaries". In order to realize this aim students were provided with the sub-themes of Family and Tradition, Cultural Influence on Language and Dialects, Meaning of Life and Religion, Cultural Stereotypes and Prejudices and Collaborative Projects. Each participant was paired with other participants having a culture other than his\her own to make sure each participant gets to know a different culture. Participants had discussions, chats, and collaborative student projects on the sub-themes in nine different virtual classrooms during Zoom meetings which lasted about 4-5 hours each day. All participants received a certificate of participation at the end of the program.

METHODOLOGY

A total of 10 prospective English language teachers participated in the current study. Five of them were female and five were male adults from 21 to 23 years of age. They were all from Turkiye and they were not familiar with cultures other than their own. They were very curious about the exchange programs because none of them had ever been to a European country or the U.S.A. When the opportunity arose their instructor who is also one of the researchers of this study contacted the junior and senior students and informed them about the program. Six senior and five junior students volunteered. However, one senior student from Hatay could not attend because during the earthquake they lost their home in Hatay and had to move to their home in a village where they did not have a stable internet connection. All participants took place in this study with their pseudonyms. An ethical consent for the current study was granted by a higher education institution.

The aim of this study was to determine the perceptions of prospective English language teachers of a virtual student exchange program of their perceived skill development in open and distance learning settings. In order to fulfill the purposes of the current research study, qualitative methods were employed. Being a qualitative research model, case studies evaluate an issue specific to a particular situation holistically (Yin, 2009). In this case study, the prospective English language teachers' likely skill development practices were determined qualitatively.

The data were collected through reflective essays written by each participant each day at the end of the exchange sessions. Each participant wrote eight essays so in total eighty essays were collected. One of the researchers of the study participated in the program as an assessor and moderator and hence had a chance to observe the participants who were located in her class in the exchange setting. They also had a WhatsApp group where they communicated about what to do and how because at times the participants were not clear about what was expected from them. All in all, the main data originated from the reflective essays and the data were triangulated with observations and WhatsApp chat texts.

The textual data elicited through reflective essays were coded first and classified later to reveal the themes. Once the codes were determined by the two researchers separately, cross-checking for the codes was conducted for reliability reasons. Next, the codes were grouped under certain categories to reveal the themes. Each researcher coded the data separately in order to ensure reliability. In order to ensure the validity and the reliability of the data analysis, the participants' opinions were directly included.

FINDINGS AND DISCUSSION

The findings are listed below and discussed under the three themes of developed learning, life skills, and enhanced internal gains.

Developed Learning and Life Skills

Regarding learning and life skill development, all participants reported great efficacy. Learning skills encompass critical thinking skills, creativity, collaboration, and communication. Amongst these four skills, collaboration was the most referred learning skill (n = 21) and all participants mentioned this skill. As Aisha noted:

> *With the help of the GAP exchange program, I developed myself in various ways. For example, my intercultural team working skills are developed. Because I participated in group projects. All the projects were group activities and all members were of differing nationalities. I think they did this on purpose because they wanted to see how we will find a common ground. One of these group projects was a role-play activity. That is why, it required lots of communication, discussion, balance, and harmony among the members. While preparing our group project, we discussed and shared our ideas. We also, listen to each other but there were quiet types and talkative ones. I am a talkative type but seeing that some people did not speak, I willingly gave the floor to them. I can say, it is good for me.*

Ali believed collaboration with foreign team members was both beneficial and difficult. He stated:

> *Thanks to the exchange program, I had the opportunity to work with foreigners. My group members were from the Philippines, Nigeria, Cyprus and India. At first, I guess it was difficult for everyone to understand what the activities required. We had to do something to overcome this difficulty and then the guy from the Philippines offered a solution. He suggested brainstorming about what needed to be done. Then each of us spoke about our ideas. For example, the first activity was festivals. It was too general. There are national ones and local ones, food festivals, beer festivals, religious festivals. The Indian member asked if carnivals are festivals or not. There were lots of questions and I was a little overwhelmed because we were in short of time. I suggested voting and we said yes carnivals count, too. Then the question of which festivals from which countries was posed. Then, the Cypriot guy suggested that each member should choose two festivals or carnivals either local or national from his\her own country and prepare a PowerPoint presentation on them, like a 12minute presentation. It was fair enough and we all agreed. Then the issue of who would compile the slides so that we will come up with one. One member volunteered for this. And we needed someone to give the speech. All of us volunteered because we all wanted to represent the group. Not to offend anyone and include everyone we decided that each member presents the slides that she\he has prepared. Fair enough.*

The above quotations vividly depict strategies for fostering collaboration among individuals of diverse nationalities, emphasizing shared goals and problem-solving approaches. Transposing this insight into the context of open and distance learning (ODL), it is apparent that these collaborative dynamics are equally relevant in virtual spaces. The examples provided underscore the importance of cultivating a willingness among participants in Ali's group to actively engage and contribute to the collective improvement of the group's endeavors, a principle that holds true in the ODL environment. In the realm of ODL, where physical presence is not a prerequisite, the ability to work collaboratively for a common purpose becomes even more critical. Reading between the lines of the narrative, it becomes evident that each member of Ali's group, while aspiring to distinguish themselves, demonstrated a commendable capacity for compromise. This quality is foundational in ODL, where individuals from diverse backgrounds converge in virtual spaces, necessitating a harmonious balance between individual aspirations and collective objectives. The observations made in traditional classroom settings, as mentioned in the text, find resonance in the ODL landscape. The emphasis on respect, careful consideration to avoid interruptions, and an open and welcoming attitude toward diverse ideas align with the collaborative ethos essential in virtual learning environments. Importantly, the endorsement of these findings through WhatsApp text messages highlights the ongoing commitment to reconciliation and problem-solving – a testament to the enduring relevance of collaborative skills in both physical and virtual learning spaces. Furthermore, the reference to Hadianto's (2019) study underscores the enduring nature of these collaborative principles, emphasizing that collaborative skills are not only applicable in face-to-face classroom activities but are also enhanced through various modes of learning, including e-learning within the ODL framework. Thus, the collaborative dynamics illustrated in the original text find resonance in the context of open and distance learning, emphasizing the enduring importance of fostering collaborative skills across diverse educational settings.

Communication is the second most mentioned learning skill (n=19). Nine participants highlighted the importance of communication and how they benefitted in terms of communication skills. Kerem commented:

> *Also, my international communication skills are developed. Because I had the opportunity to communicate with people from different cultures. At some points, it was challenging to understand their accents but I figured it out.*

It was crucial for the participants to learn how to effectively convey ideas among people of different nationalities and cultures. Misunderstandings could occur due to cultural differences, differing accents, and English varieties. Effective communication could at times be one of the most underrated skills but like any other skill it needs to be taught and learned. All the participants took a course called Effective Communication during their first semester at the Department of English Language Teaching. Thus, they were all aware of the importance of effective communication and the role culture plays in effective communication. In this exchange program they had the opportunity to put what they learned into practice. Class observations and WhatsApp chat data also supported this finding. Two students highlighted the need of being respectful when discussing activities with the members and the importance of using appropriate language. On communication, Melisa had this to say:

> *As it was an international program, we were working with people who had different cultures. I knew that a normal word in my culture could be offensive in another culture. I was very careful to avoid such offensive words because they did not know Turkish culture and this could create problems.*

Cansu raised her worries:

> *The first shock came to me on the first day. During the opening ceremony a pastor gave one of the speeches and it was about the meaning of life. That the meaning of life was handled from the religious viewpoint was awkward to me but I did not ask the reason for it in case they are offended.*

All participants mentioned problems resulting from different accents. In order to overcome this problem, they had the interlocutors repeat what they said politely. The finding that the participants developed effective communication skills verified Hadianto (2019) that student exchange programs led to gains in effective communication.

Developed critical skills were the third most mentioned learning skill (n=3). Critical thinking entails finding meaningful solutions to problems and is conducive to improvement in general and professional development in particular. Hossein noted:

> *Once the duties were shared among the members of my group for the first activity on the first day we did not communicate further until we meet the next day. But I felt the need for their ideas on whether or not I was on the right track. So, I suggested forming a group of our own on Google Space. The other members also found this useful. By this way we had timely discussions.*

The current study found that student exchange program resulted in fostered critical thinking skills, which supported Hadianto (2019) that the participants' critical thinking skills were boosted through an exchange program.

Creativity was the least frequently mentioned learning skill. Creativity empowers individuals to see concepts from a different perspective, which leads to innovation. Tom commented on how his creativity was triggered:

> *As we reflected every day at the end of the sessions, I found myself reporting on what went well and what did not go so well. I thought it would be beneficial for the host college to know the aspects of the exchange we liked most as well as the aspects to be improved. For this reason, at the end of the exchange I wrote a thank you letter to the head of the college and kindly added my views on the things to be improved because I know that they will keep organizing such programs in the future and if they take my criticism seriously, they can improve themselves better.*

Despite the fact that creativity was the least frequently mentioned skill, it is valuable that a student benefitted in terms of creativity. This result went in line with that of Hadianto (2019) that a student exchange programme led to fostered creativity among the participants.

Developed Life Skills

In the context of open and distance learning (ODL), the delineation of 21st-century life skills, encompassing social skills, flexibility, leadership, initiative, and productivity, gains significant relevance. These skills are integral to navigating the complexities of virtual and technology-driven educational landscapes. Within the spectrum of ODL, social skills emerge as particularly crucial, mirroring the emphasis placed on this skill in the original text. In the ODL environment, where physical interactions are often limited, the cultivation of social skills takes on added importance. The acknowledgment that social skills were predominantly highlighted among the enumerated life skills resonates with the collaborative nature of ODL. Participants in

ODL programs frequently emphasize the significance of establishing connections, making new friends, and valuing the relationships forged in virtual spaces.

Aisha's commentary, expressing a desire for more time to spend with newfound friends, aligns with the social dynamics inherent in ODL. In virtual learning environments, fostering a sense of community and camaraderie is essential for student engagement and satisfaction. Aisha's sentiment reflects the interpersonal connections formed in the digital realm, illustrating how virtual interactions can be as impactful as face-to-face encounters. Importantly, the emphasis on social skills in the ODL context extends beyond casual interactions. Effective collaboration, communication, and teamwork are integral components of successful online learning experiences. Participants in ODL programs often highlight the collaborative and supportive nature of virtual communities, emphasizing the role of social skills in creating a conducive learning environment.

Hossein added socializing was one of the advantages of the exchange program. Tom commented:

> *I was pleased with getting to know many university students coming together and also making connections with the teachers from other countries. I was so curious about them that I made use of every learned some words in their native language to get closer. I believe they really liked hearing me say those words albeit sometimes they did not understand the words I said.*

Having effective social skills is crucial to long-lasting relationships and building a rapport. A teacher needs to develop effective social skills to make connections with his\her students and colleagues.

Eight participants mentioned flexibility (n=10). Flexibility refers to the ability to make changes and deviate from something planned so as to adapt to the changing circumstances. Miriam reported:

> *All my group members got along well. We were all open to new ideas and respected each other's suggestions. At one time we were preparing a presentation on world heritage. Once we picked the sites to be included, the Indian guy suggested adding an authentic perspective by including some words in the native language of the site where it was located. For example, if the site was in Turkiye, we would add a sentence like 'Sizi seviyoruz' which means 'we love you' in Turkish. I argued that this was pointless as most people would not be able to understand because only eleven participants including our professor knew Turkish. Some other members supported me, some others the Hindu guy but I did not want to create confusion so I said let's give it a try and that it could work. We did not receive negative feedback at the end of the presentation and this made me happy.*

Flexibility entails acknowledging others' ideas and accepting them in order for the good of the team and hence it is essential for prospective English language teachers to be successful in their careers. This is also a skill that will help them in life. In this case, Mirim did not insist on her ideas to be accepted. Instead, she showed that she was welcoming towards change for the good of the team.

Leadership requires the skills to be able to set goals, monitor the team members in accomplishing these goals and motivate them to work collaboratively for the benefit of the team. Only two participants wrote that they improved their leadership qualities through this exchange program. Cansu commented:

> *In my group everyone was quiet at first. We did not know each other and not everyone was willing to speak. When we were given the activities, there were lots of things to be done. I am sure everyone would prefer to do individual work but we needed to work in groups. Some people are born as leaders-natural leaders. I cannot describe myself as a leader. But there were lots of things to be done and we needed to start at once. The title of the activity was Wedding Ceremonies. Thus, I decided to handle the planning stage. First, I asked every member to brief us about the wedding ceremonies in their homeland and asked them to prepare some visuals. I did so too. I formed a WhatsApp group with them immediately and asked them to share their visuals there. I also shared my visuals. Then we decided which visuals to include in our presentation. I think they like me because in the next activity they also let me plan everything.*

As this quotation illustrated, Cansu worked with her group members, united everyone under a common goal, and had everyone work for the collective benefit of all. She must have inspired and ensured a positive work culture since she was also accepted as the group leader for the upcoming activities. Classroom observation data also verified this finding.

The data did not reveal any information about initiative and productivity.

Enhanced Internal Gains

In terms of gains, most participants reported internal outcomes, such as self-confidence, empathy, and self-reliance. The reason for the lack of external outcomes can be due to the brevity of the exchange programme. All participants reported developed self-confidence. As the participants had the opportunity to work with people from diverse backgrounds and cultures, they gained a deeper understanding of cultures other than their own as well as themselves, leading to various forms of personal growth. Rachel enclosed:

> *This exchange program is my first international experience. Initially I was willing but nervous at the same time. Turkish students wonder about foreigners a lot. I really want to get to know other cultures. There were also many worries and questions in my mind. Is my English good enough? What if others do not like me? Who will help me when I have a problem? During the first day they explained everything in like two hours but still I had many questions. Our instructor did the follow up very well. For example, they placed us in classrooms by the usernames in our PCs. Mine is different from my name. So, I could not find my name in any class list. I stressed out and panicked. My instructor helped me write to the organizing committee. My problem was solved immediately. My team members were also very helpful and understanding. Starting from the second day I felt more at ease and knew that the people I around me were supportive and friendly. They respected my ideas and valued my opinions. They made me feel valuable for them. They liked my accent and I felt powerful.*

As illustrated in the above quotation, Rachel developed self-confidence through this international experience. In this respect, this result went in line with the result of Gray, Murdock, and Stebbins (2002) and Giedt et al. (2015) that a study abroad experience led to gains in confidence and maturity among the student participants. This result also verified Brodin (2010) that exchange programs provided opportunities for increased self-esteem.

Emphatic individuals are expected to develop an increased understanding, sensitivity, and connection to another culture in multicultural open and distance learning settings. Only four participants referred to empathy as an internal gain. Chris argued:

> *From the very beginning, I was ready to mix with people with different cultures and traditions. This is a sensitive and delicate issue. From the course called pragmatics I have taken in the department I knew that people get different messages from verbal and nonverbal clues and messages. The thing was that although we studied British and American culture, I was not familiar with Hindu, African and Filipino culture. Not to offend anyone I approached people with respect, tried to understand their feelings and values imposed by their traditions and cultures. Although some of them were really strange like the seat system. Whether or not a student would have a seat in the class depended on his\her grades. I think the purpose was to encourage students for academic success.*

This study found that the exchange program helped some participants develop empathy. In this respect, our results echoed that of Gray, Murdock, and Stebbins (2002) that the student participants who had a study abroad experience acquired emphatic gains.

Self-reliance refers to relying on oneself rather that others and functioning independently. It was found that two participants developed self-reliance. Chris commented:

> *I learnt from this international experience that I can do many things on my own. I felt free because I can manage on my own. If I like I can enroll in an MA program abroad because I now know that I can communicate with them and make friends with them and that I know English opens many doors to me. I feel like a global citizen who no longer dependent on my homeland. I realized this through this exchange program.*

This result went in line with Sindt's (2007) result that the participants benefitted internal gains, such as autonomy and independence. Similarly, this result echoed Edmond (2010) that student exchange led to positive gains in terms of personal growth, awareness and self-efficacy. This result also went in line with Brodin (2010) that exchange program contributed to gaining independence.

CONCLUSION

Globalization has exerted a profound impact, particularly on tertiary education. As we consider the implications within the context of open and distance learning (ODL), it becomes evident that students, teachers, and aspiring educators participating in this expanding globalized landscape must not only acknowledge but actively engage with the diverse perspectives inherent in globalization. This engagement is vital for the enrichment of learning practices, effective functioning in the contemporary world, and navigating careers successfully within present-day schools.

Within the realm of ODL, the integration of videoconferencing technologies plays a pivotal role in fostering interaction among international students. This technological avenue not only facilitates communication but also serves as a conduit for the expansion of worldviews. Through virtual engagement, students can build new social relationships, transcending geographic boundaries, and gain insights into different cultures. In the context of ODL, videoconferencing becomes a valuable tool for creating a globalized and interconnected learning environment.

Moreover, student exchange projects, while traditionally associated with physical mobility, can also find resonance in the realm of ODL. These projects serve as invaluable platforms for embracing cultural diversity, a concept that is equally applicable in the virtual space of open and distance learning. Participating in such initiatives, whether physically or virtually, becomes a means of developing skills to function adeptly in a multicultural academic environment and broadening one's horizon.

In alignment with these principles, a study conducted within the framework of open and distance learning discovered that prospective English language teachers, when immersed in a student exchange program – which could extend into the virtual sphere in ODL – had the opportunity not only to appreciate cultural diversity but also to develop specific skills crucial for their roles. This underscores the relevance of incorporating global perspectives within the context of open and distance learning, emphasizing the transformative potential of virtual interactions and collaborative endeavors in enhancing the educational experience. More specifically, the exchange program led to developed critical thinking skills, creativity, collaboration and communication which were all learning skills. It was found that the most frequently mentioned skill was collaboration and the least creativity amongst these learning skills. It shows that the virtual student exchange program contributes to the development of some skills, raises awareness on multiculturalism and improves language skills through practice. Additionally, the results revealed that some life skills, such as social skills, flexibility and leadership were fostered but initiative and productivity were not. Regarding gains, rather than external gains, internal outcomes, such as self-confidence, empathy and self-reliance were reported to be enhanced. For future studies, we suggest that studies employing ethnographic research designs can provide deeper insights as to skill development.

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