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Gamified Mobile Virtual Laboratory for Indonesian Language Learning

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Abstract

This study introduces a gamified virtual language laboratory (lab) designed for mobile platforms, employing quiz-based content to bolster interaction and engagement in online Indonesian language learning. To see the effectiveness of the proposed application, the first two levels of the Kirkpatrick model have been carried out, namely reaction and learning evaluation. A quasi-experiment was conducted involving 260 first-year undergraduate students, divided into an experimental group and a control group, who underwent a pretest, learning activities, and a posttest. First, the reaction level utilized a 38-item questionnaire to measure usability, game experience, and interactive learning perception, with strong correlations ($r > 0.5$) and high internal consistency (*alpha* = 0.964) confirming the validity and reliability of the data and revealing positive student attitudes through descriptive statistics. Second, the evaluation of the learning level encompassed pretest and posttest scores from 60 questions. This analysis employed the Mann-Whitney *U* test with an Asym. Sig. (2-tailed) value of 0.001, indicating a significant difference in learning outcomes. The experimental group showed a higher mean score gain (pretest = 65.94; posttest = 82.94) compared to the control group (pretest = 71.50; posttest = 77.66). These findings underscore the efficacy of the gamified approach in enhancing Indonesian language learning.

Keywords: virtual language lab, gamified learning, quiz game, online learning, language learning.

Introduction

Over the years, most prior studies have generally accepted that practical experiences have positively supported students in gaining comprehensive knowledge and skills through a "learning by doing" approach (Jara et al., 2011; Seifan et al., 2020; Woodfield et al., 2005). From an academic point of view, practical experiences are primarily conducted in laboratories, allowing students to improve their understanding of theories and concepts through actual phenomena. Virtual laboratories are computer-based simulations presented in either two or three dimensions (Reeves & Crippen, 2021). These simulations place the students in a virtual version of a physical laboratory, allowing them to interact with virtual equipment and materials remotely (Budai & Kuczmann, 2018). The use of virtual laboratories has emerged in many prior studies to support students' practice before, during, and after practical sessions (Altalbe, 2019; Dalgarno et al., 2009). Nowadays, mobile technology has gained significant popularity as a prominent platform with the potential to incorporate laboratory activities through a range of applications (Sophonhiranrak, 2021). The use of smartphones, tablets, and similar devices can simulate all kinds of practical activities and possibly combine with hands-on laboratory classes. Mobile virtual laboratory applications may offer a variety of learning opportunities, including personalized learning, interactivity, collaboration, easy access to any learning content and activities, and communication that is not limited by space or time (Martin et al., 2020). One of the challenges in using virtual laboratories for learning is how to enhance student engagement and motivation to participate in and complete virtual assignments (Bahr et al., 2023). To increase students' motivation in learning, the use of game elements in the virtual laboratory approach has aided the pedagogical strategy (Bahr et al., 2023; Iquira et al., 2019; Tauber et al., 2022). The utilization of game elements in virtual laboratories was practically applied in most educational levels and covered many subject areas, including computer, mathematics, science, and linguistics (Martin et al., 2020). The use of game elements, such as badges, points, leaderboard, levels, and direct feedback are frequently mentioned in several study reviews (Dehghanzadeh et al., 2021). This strategy has been reported to provide a joyful learning experience while improving students' motivation, attitudes, and academic achievements (Elaish et al., 2019; Subhash & Cudney, 2018). The term "gamified mobile virtual laboratory" in this research refers to the implementation of game elements in the context of a mobile-based virtual laboratory application as a strategy to enhance student learning motivation, as previously explained.

The concept of virtual laboratories for language learning is not a new idea. According to a literature search conducted on Google Scholar using the keywords "virtual language lab" or "virtual language laboratory," the terminology was initially introduced in 1993, referring to a form of computer-assisted language learning (CALL) that uses digital audio materials for learning foreign language that can be accessed interactively and remotely via telephone by students, providing a virtual experience like in a regular classroom (Richmond, 1993). Then, in 1999, the same term was also used for a web-based virtual learning environment created to replace tape-based language laboratories in order to facilitate EFL (English as a Foreign Language) students in Taiwan to practice listening skills without the limitations of space and time (H.-J. H. Chen, 1999). In 2011, a dozen years later, the phrase "virtual language lab" resurfaced, this time denoting the utilization of mobile and cloud technology to fulfill language center requirements. This extended beyond the traditional role of virtual language labs in the 1990s, which primarily focused on listening skill practice. Instead, it encompassed a wider range of functions, including asynchronous written communication, collaborative content creation, technology tailored for specific textbooks, video interfaces, virtual reality, social

networking platforms, and communication tools (MacDonald, 2011). Most recently, in 2012 and 2013, the term "virtual language lab" was used to refer to an intelligent computer-assisted language learning (ICALL) system known as WordBricks (Mozgovoy, 2012; Mozgovoy & Efimov, 2013). This system relied on artificial intelligence, particularly natural language processing, to assist students in practicing the construction of grammatically correct English sentences (Mozgovoy, 2012; Mozgovoy & Efimov, 2013). Based on the literature found, the focus of the virtual language lab is on foreign or second language acquisition, especially EFL.

Research related to gamified language learning has significantly increased in the last decade (Krath et al., 2021; Shortt et al., 2021). In line with the virtual language lab, English has become the most popular target language (Su et al., 2021).Most non-English speaking countries frequently used Duolingo to learn English (Shortt et al., 2021). Other popular gamified applications, such as Kahoot! (Y. M. Chen, 2022; Licorish et al., 2018), Quizizz (Lim & Yunus, 2021), and WordBricks (Purgina et al., 2020) have also been utilized as part of classroom activities in English language teaching and learning. Referring to the previous studies, gamified applications for language learning are widely used to assist students in acquiring specific language knowledge, such as grammar (Purgina et al., 2020), vocabulary (Elaish et al., 2019), and other various skills (e.g., speaking, writing, reading, and listening) (Dehghanzadeh et al., 2021; Shortt et al., 2021). However, there is limited evidence of study and application focusing on assisting students who have achieved an advanced proficiency level, especially in non-English languages (Han, 2019).

In a comprehensive literature review article, regarding mobile and non-mobile games for language learning, apart from English, there were several other languages targeted, such as Chinese, Spanish, Turkish, Dutch, German, French, Italian, Japanese, and Swedish (Su et al., 2021). No one has discussed Indonesian yet. According to government regulation number 57 of 2014 (Indonesia), Indonesian is the official language of the Republic of Indonesia and is used in various domains, such as state needs, the world of education, communication needs at the national level, documentation needs, and trade or buying and selling transactions, use and development of science and technology and art, and mass media needs. Therefore, Indonesian citizens, including students, must attain a high level of proficiency to effectively engage in everyday conversations and excel in both general and academic reading and writing. The Indonesian language must follow language standardization, namely The Enhanced Spelling of the Indonesian Language (Indonesia: Ejaan Bahasa Indonesia yang Disempurnakan, EYD). However, a rapid change in the EYD system and limited resources to learn EYD have become serious issues, especially in writing skills. Still, several spelling errors, such as the use of punctuation, capital letters, affixes and prepositions, and typographical errors are currently found in academic writing (Asih et al., 2018; Leksono, 2019; Rosdiana, 2020; Turistiani, 2014), essays and dialogues (Ariningsih et al., 2012; Khoirurrohman Taufiq, 2018; Qhadafi, 2018), and mass media (Winata, 2019).

To be able to write well and correctly, students must know the applicable EYD. In formal education, students gain knowledge of EYD from Indonesian language subjects or courses, which are mandatory content in the national curriculum for higher education. Online learning, which has increased in popularity during the COVID-19 pandemic, has given rise to challenges from both students and lecturers, such as lack of interaction between students and lecturers (Adnan, 2020) and lack of student engagement in online learning (Nuci et al., 2021). Interaction and engagement are the main parameters that can be analyzed to see the level of student motivation in online learning (Nuci et al., 2021). Lack of interaction and engagement can be a sign that online learning is less effective (Adnan, 2020). Lack of motivation to learn can result in a deficiency of acquired knowledge (Afni et al., 2022; Rianita et al., 2020).

This research aims to help students gain knowledge of Indonesian spelling using a gamified mobile virtual laboratory application. Especially to help them stay motivated while studying through online learning. The study will explore students' perspectives and assess the effectiveness of implementation by comparing traditional online learning methods with interactive online learning facilitated by the proposed application. Thus, this study addresses two research questions:

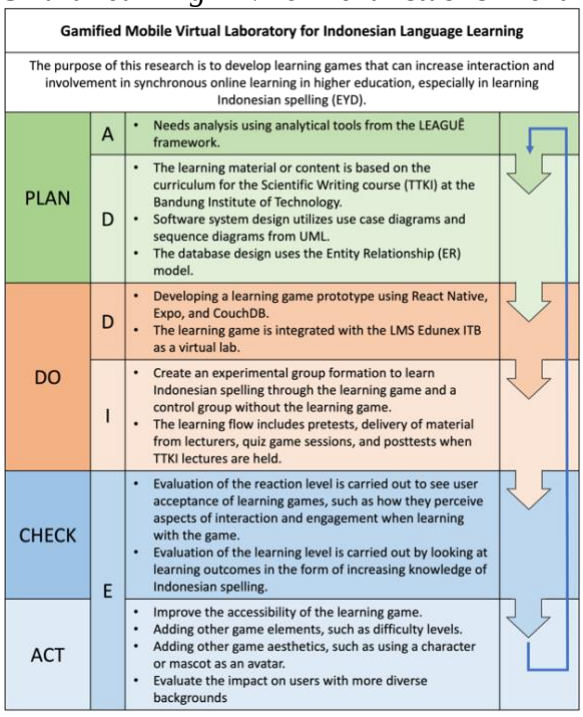
1. RQ1: What are the students' perceptions of the gamified mobile virtual laboratory for learning the enhanced spelling of the Indonesian language (EYD)?
2. RQ2: What is the effect of using a gamified mobile virtual laboratory on students' knowledge of the enhanced spelling of the Indonesian language (EYD)?

Materials and Methods

A smart learning environment guideline (SLEEG) was adopted to plan application development, which followed an ISO 21001:2018 standard and ADDIE approaches (Rosmansyah et al., 2023). The detailed process undertaken in this study is available in Figure 1. The gamified mobile virtual laboratory application proposed in this study is called Jago PUEBI.

Figure 1

Smart Learning Environment Establishment Guideline (Rosmansyah et al., 2023)



Planning Phase of Jago PUEBI

During the planning phase of the study, researchers undertook a comprehensive analysis of the requirements inherent to the learning game. This process was facilitated through the utilization of analytical tools aligned with the LEAGUÊ framework (Tahir & Wang, 2020), which encompasses six critical dimensions: Learning, Environment, Affective-Cognitive Reactions, Game Factors, Usability, and UsÊr.

Learning

To effectively assess the learning dimension, it is imperative to address four fundamental inquiries. These questions delve into the attributes of learning games that actively promote and enhance the learning process. For a comprehensive overview of these questions, please refer to Figure 2.

Figure 2

Learning Dimension Analysis

Learning		
Code	**Question**	**Answer**
L1	What are the learning objectives of the game?	Students can improve their knowledge of Indonesian spelling by playing the game.
L2	Which learning strategies are being used in the game for target users?	Learners engage in interactive quizzes centered around Indonesian spelling, where they answer questions and receive instant feedback containing the accurate solution and explanation. This approach to learning emphasizes active participation by the students.
L3	Whate learning content is being used in the game for target users?	The utilized content comprises quizzes structured and categorized according to the guidelines of the Enhanced Spelling of the Indonesian Language (EYD), encompassing letter utilization, word composition, punctuation usage, and language absorption. The content was sourced from the Indonesian spelling question repository within the Scientific Writing (TTKI) course at the Bandung Institute of Technology. It underwent validation and explanation by the instructor responsible for the course. Content is not organized by level of difficulty but is randomly assigned to target users.
L4	What learning outcome(s) can be acquired from the game?	Enhancing Indonesian spelling knowledge is expected to reduce the level of Indonesian spelling errors in students' written works.

Environment

To analyze the environmental aspect, two essential questions need addressing. These pertain to the practical application of learning games within the prevailing environmental conditions. For a comprehensive overview of these questions, please refer to Figure 3.

Figure 3

Environment Dimension Analysis

Environment		
Code	**Question**	**Answer**
E1	What technical aspects are required for the game to work and best support learning?	A tablet or smartphone with the Android or iOS operating system and an internet connection are required to play the game.
E2	What is the context for playing the game for learning?	This learning game offers the flexibility of multiplayer engagement from various locations. In the context of this research, the game is designed to be employed in online educational settings, specifically targeting the enhancement of Indonesian spelling skills. This involves the active participation of all enrolled students in competitive gameplay. A prerequisite for participation is possession of a Learning Management System (LMS) account, which grants access to quiz-based gaming sessions seamlessly integrated into the classroom's LMS-linked learning modules. Furthermore, a solo mode is also available, allowing individuals to practice Indonesian spelling autonomously, unhindered by time or location constraints.

Affective-Cognitive Reactions

To analyze the environmental aspect, two essential questions need addressing. These pertain to the practical application of learning games within the prevailing environmental conditions. For a comprehensive overview of these questions, please refer to Figure 4.

Figure 4
Affective-Cognitive Reactions Dimension Analysis

Affective-Cognitive Reactions		
Code	**Question**	**Answer**
A1	How can the game provide enjoyment to the users?	The game employs user interaction in a social manner, particularly through competitive attempts to respond to quiz questions swiftly and accurately with the aim of achieving excellence. Additionally, the game offers instant feedback and detailed explanations regarding the actions taken.
A2	How can the game engage the users?	The game motivates each player to engage by presenting them with the allure of being challenged through simple questions and unpredictable answers.
A3	How can the game motivate the users?	The quiz questions are made based on common mistakes in writing Indonesian spelling, aiming to connect the game with players' everyday encounters for a sense of relevance.
A4	How can the game generate flow?	The game demands the player's full concentration due to the limited duration of time to answer the quiz questions. Players will also have a valuable experience when they gain new knowledge from the game through feedback when they answer questions incorrectly.

Game Factors

To analyze the environmental aspect, two essential questions need addressing. These pertain to the practical application of learning games within the prevailing environmental conditions. For a comprehensive overview of these questions, please refer to Figure 5.

Figure 5
Game Factos Dimension Analysis

Game Factors		
Code	**Question**	**Answer**
G1	What are the game objectives to integrate learning?	Players respond to questions within a quiz session arranged by the host, either the lecturer or the teaching assistant. The host can determine the purpose of learning through games and randomize questions from one or more EYD categories (the use of letters, the use of words, the use of punctuation, and the use of absorption elements) according to learning objectives.
G2	What narrative is used to make game compelling and integrate learning?	Each player playing the game will be a single character with an initial avatar and name in text form, which will be visible to other players. This character will compete and will appear on the leaderboard.
G3	What mechanics are used to make game compelling and support learning?	The game is played with a simple touch on the screen. There are two to four buttons that can be selected to determine the answer to a question, and one button to confirm and send the answer choices. In multiplayer mode, there are no buttons to continue to the next question or return to the previous question; the movement of questions is fully controlled by the host. What's interesting is the existence of social interaction between players in the form of competition to collect the most points and appear at the top of the leaderboard.
G4	What resources are provided to the users to function effectively that also support learning?	Guidelines are provided detailing how players can participate in a quiz game session using a distinct game access code presented on the host's screen. Avatars are utilized to depict the players within the game. A waiting area showcases participants who have joined and are prepared to engage. A timer is in place to notify players about the remaining time for responding to questions. Points are allocated as rewards to each player upon answering questions, with computation based on answer precision and swiftness. Instant feedback is supplied for every response submitted by the player. A leaderboard is present to communicate the player's standing relative to earned points.
G5	What aesthetics are used to make game compelling for tarteg users?	Overall, the game is text-based with simple fonts designed for smartphone or tablet screens. Random, attractive color rendering is also given to the background of the buttons. There are interesting animations in response to different answers, whether the player answers correctly or incorrectly. Apart from that, there are also interesting audio effects according to the response of the answers and audio effects that are in sync with the timer. At the end of the game, there is an audio effect and a podium animation showing the top three rankings.
G6	What game play is used to make game compelling for target users and support learning?	The game demands the player's full concentration and attention to answer questions within a short period of time. Players must answer questions that look simple, tricky, and very relevant to everyday life. When players answer correctly, they will be awarded points based on the speed and accuracy with which they answer. When players answer incorrectly or are late in answering questions, they do not get points; they will gain new knowledge through instant feedback, which is given to provide explanations and determine which answers are correct. Apart from that, players will also feel challenged to answer the questions correctly.

Usability

Three inquiries need to be addressed to assess the usability dimension. These questions pertain to the degree to which users can effectively employ learning games to accomplish specific objectives. This encompasses aspects such as learning efficacy, comprehension,

control, and user satisfaction. For a comprehensive overview of these questions, please refer to Figure 6.

Figure 6
Usability Dimension Analysis

Usability		
Code	**Question**	**Answer**
U1	How does the interface of the game made easy to use for target users?	The game has a simple and consistent interface on every screen, can adapt to various smartphone or tablet screen sizes, uses an attractive and consistent color scheme, and allows easy navigation with icons or buttons to move or access certain screens.
U2	How does the game provide easy learnability to its target users?	It is easy to enter or log into the game using an LMS account that is already owned by players, so they are used to it and are familiar with it. In addition, it is easy to access the quiz game session through the game access code. The access code input form is displayed on the home screen and is placed at the top so that players can easily find it. Furthermore, in the quiz session, players can intuitively choose answers and send answers via buttons with a size that is quite large, and a contrasting color, so that it is easy to touch.
U3	How does the game provide satisfaction to its target users?	There is the use of interesting audio and animation effects that are adjusted to the player's answer choices, as well as audio effects that adjust to the timer. In addition, there is also the use of bright colors on the button background.

UsÊr

Three inquiries need to be addressed to assess the usability dimension. These questions pertain to the degree to which users can effectively employ learning games to accomplish specific objectives. This encompasses aspects such as learning efficacy, comprehension, control, and user satisfaction. For a comprehensive overview of these questions, please refer to Figure 7.

Figure 7
UsÊr Dimension Analysis

UsÊr		
Code	**Question**	**Answer**
Ê1	What are the attributes of the target users of the game?	The games are designed for both youth and adult age groups (12–45 years); there are no restrictions on gender, ethnicity, or religion. Players must be able to read and speak Indonesian. In this research, the game is aimed at students in tertiary institutions who are taking Indonesian Language or Scientific Writing courses.
Ê2	Which cognitive needs (of target users) are considered in the game?	The game is designed to be played in a short period of time and not be boring for players.
Ê3	Which psychological needs (of target users) are considered in the game?	Players feel more connected to the social environment through in-game interactions and competitions. They also feel capable of taking up the challenge of answering simple questions that are relevant to everyday life.

Design Phase of Jago PUEBI

The design phase includes software system modeling, database design, and study materials.

Software System Modelling

In this study, a widely recognized notation standard for software design called Unified Modeling Language or better known as UML (Ciccozzi et al., 2019; Cook, 2012) is employed. The diagram that will be created at this design stage is a use case diagram. Figure 8 shows the use case diagram from Jago PUEBI. There are two actors involved in the system, namely the lecturer or assistant and the student. Apart from that, there are seven use cases: Login with an LMS account (use case for the authentication process to the system using an existing Learning Management System account), Get Active Courses in LMS (use case for getting a list of active courses in LMS) Get Modules from a Course in LMS (use case to get modules from courses in LMS), Create a quiz (use case to create a quiz session), Get Quiz List from a Module (use case to get a list of quizzes in a course module), Control Quiz Session (use case to control an active quiz session), and Play Quiz (use case to play a quiz session).

Database Design

At this stage, entity relationship modeling (P. P. S. Chen, 1976) is carried out (the relationship between entities in the system) as shown in Figure 9. From this design, it is known that there are two strong entities, namely quiz and participant and two weak entities, namely question and answer.

Figure 8

Use Case Diagram of Jago PUEBI

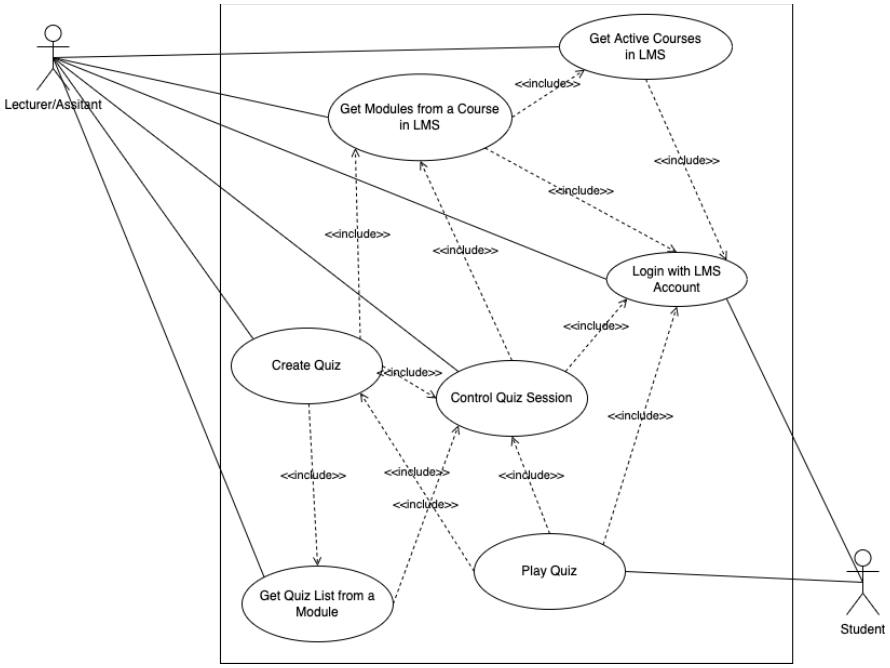
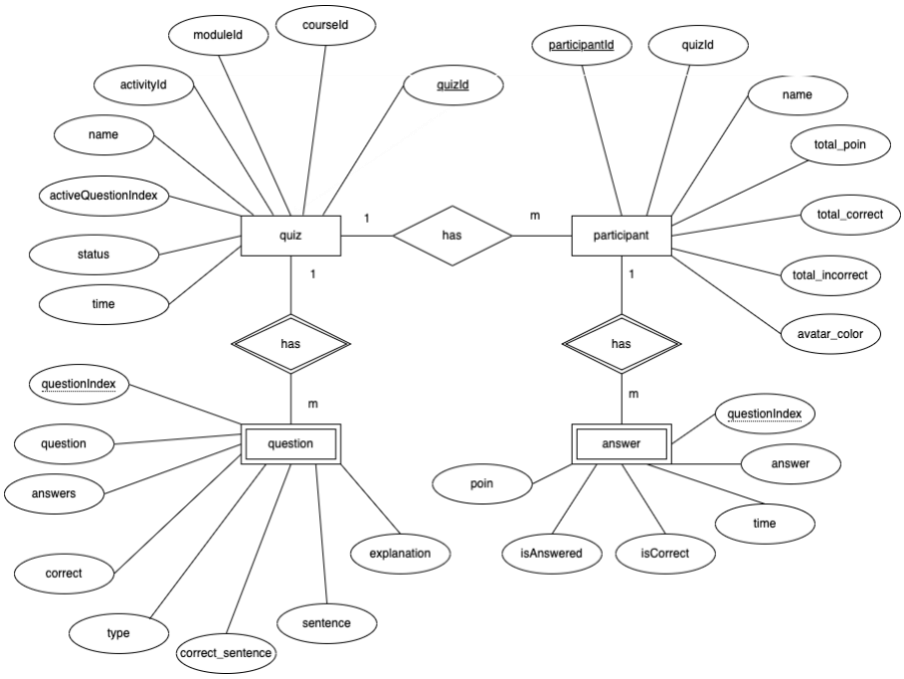


Figure 9

Entity Relationship Diagram of Jago PUEBI



Study Materials

The study materials were compiled from the Indonesian Language: Scientific Writing of Bandung Institute of Technology. The question bank was collected from 2017 to 2021. Referring to the Enhanced Spelling of the Indonesian Language (Indonesian: Ejaan Bahasa Indonesia yang Disempurnakan, EYD), these questions were divided into four main categories. The details of the question bank are presented in Table 1. This question bank has a form or scheme like the question entity in the entity relationship diagram.

Table 1
Question Bank of Indonesian Language Spelling based on EYD

Topics	Categories	Total	Question Types
Topic I	Pemakaian Huruf (The use of letters)	68	true-false
	Penulisan Kata (The use of word)	109	multiple-choice
Topic II	Pemakaian Tanda Baca (The use of punctuation)	68	true-false
	Penulisan Unsur Serapan (The absorption elements)	156	multiple-choice

Development Phase of Jago PUEBI

In this development process, researchers use tools consisting of hardware and software. Apart from that, the application will be integrated as a virtual laboratory in the Edunex LMS owned by the Bandung Institute of Technology.

Hardware

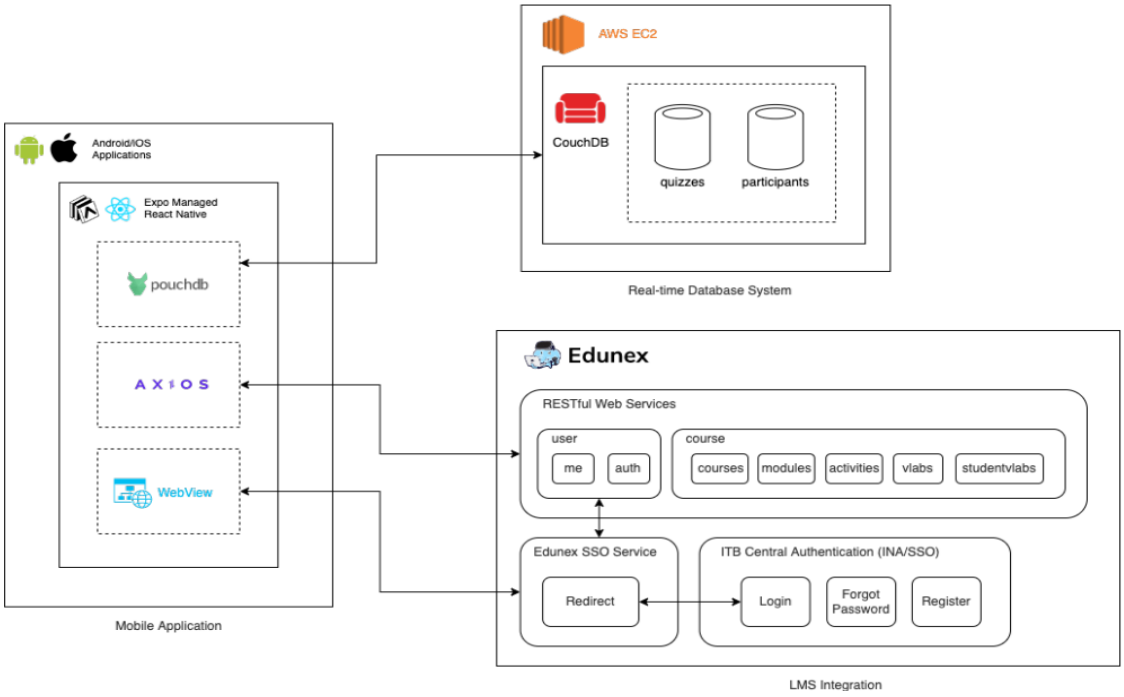
The hardware used in this research consists of several devices. The hardware used for the application creation process is an iMac (21.5-inch, Late 2012), with a 2.7 GHz Quad-Core Inter Core i5 processor and 8 GB 1600 MHz DDR3 memory. Apart from that, there is hardware to run the Jago PUEBI application, namely Android version 5 or later and iOS version 10 or later. Another device needed is a server to store the database system of the application. In this research, researchers used computing services from Amazon Web Services (AWS), namely a virtual machine with a 2nd Gen AMD EPYC™ 3.3 GHz processor, 16 vCPUs, and 32 GiB RAM.

Software

The application was crafted within the MacOS operating system environment, employing one of the industry's popular cross-platform mobile application development tools, React Native version 0.64.3, and Expo SDK version 44. Additionally, Apache CouchDB version 3.2.1 serves as the database, accessible via PouchDB in the Jago PUEBI application's source code. The codebase was authored using the JavaScript programming language (ES6+), with the Visual Studio Code editor as the development environment. Subsequently, the code was built into application packages tailored for two major mobile operating systems: Android and iOS. This build process was executed in a cloud-based setting using Expo's EAS Build

service. Finally, the applications were made available to the public through the official app stores, namely Google Play for Android and the App Store for iOS. Figure 10 shows the implemented system architecture along with the software tools used to build Jago PUEBI. This application is integrated with a learning management system, Edunex (a private LMS under the Bandung Institute of Technology), via web services.

Figure 10
System Architecture



Every actor involved in the system must be authenticated by logging in using an LMS (Learning Management System) account. At the university where the application is implemented, there is an SSO (Single Sign On) service, which makes it easier for lecturers and students to access the various services available, including the LMS. Lecturers or teaching assistants can easily create gamified quiz sessions in a course module they teach in the LMS via the interface available in Jago PUEBI. They can select the quiz material based on EYD categories, determine the number of questions, and determine the duration of each question. In this process, a unique access code will be generated, which is then distributed to students so that they can join the quiz session via the mobile application. Students participate in the gamified quiz session by inserting the access code. To achieve a higher score, students must answer the questions quickly and correctly. At the end of each question, the leaderboard appears to rank students' scores in real time. Figure 11 depicts the user interface of Jago PUEBI, and Figure 12 demonstrates the results of the leaderboard in the LMS.

Figure 11

User interfaces in Jago PUEBI

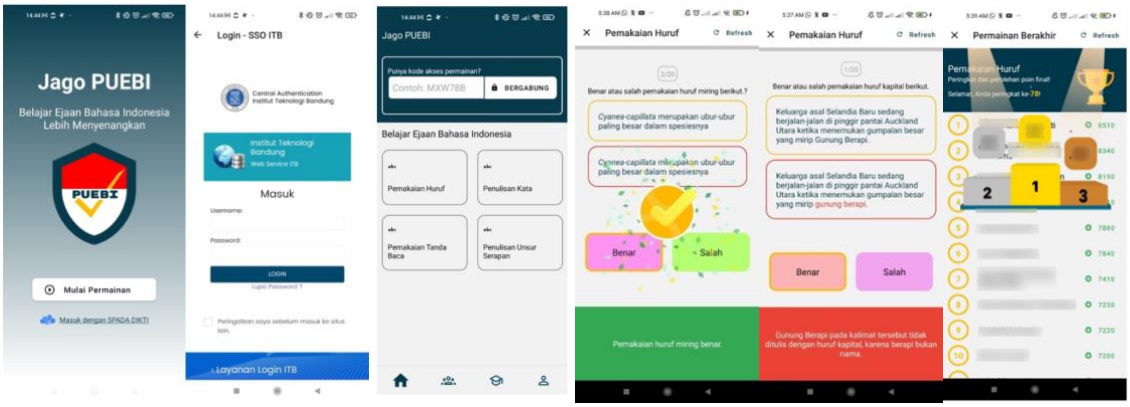
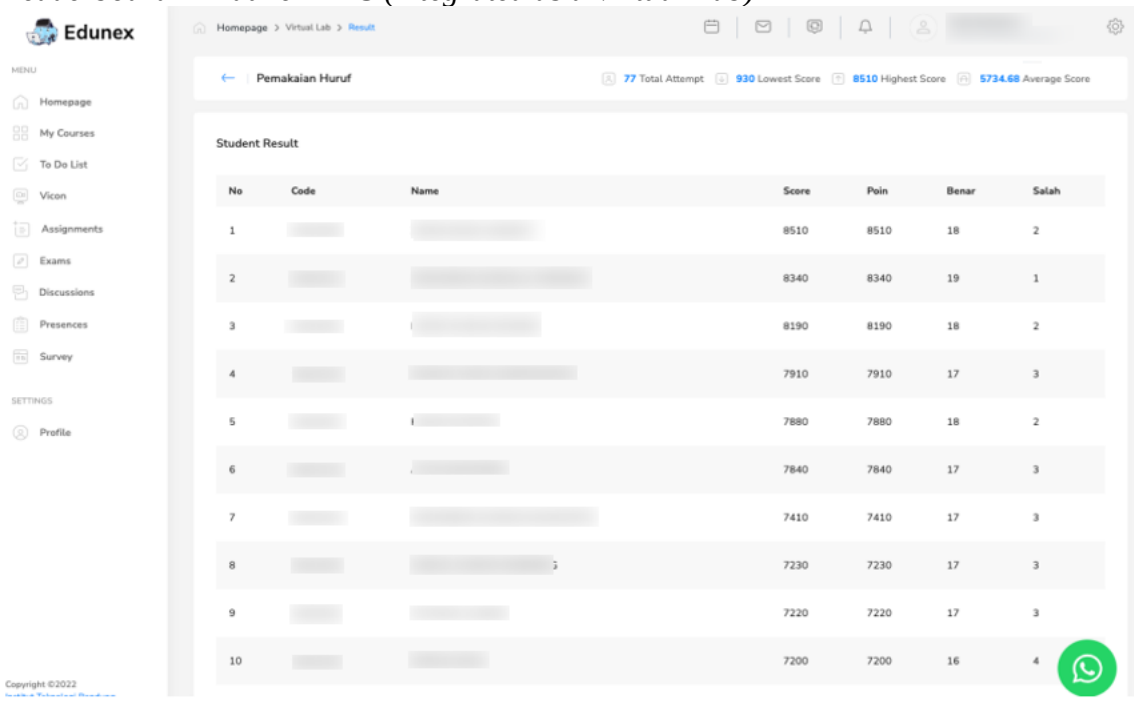


Figure 12

Leaderboard in Edunex LMS (integrated as a Virtual Lab)



Evaluation Phase of Jago PUEBI

The Kirkpatrick Model of Evaluation was adopted to evaluate the efficacy of learning methods (Kirkpatrick & Kirkpatrick, 2006). This model has four levels of evaluation: reaction (level 1), learning (level 2), behavior (level 3), and results (level 4). It is common for researchers not to do all four levels of evaluation because they usually adapt them to the research questions being conducted (Putranda et al., 2023; Sahni, 2020). In this research, only the first two levels were carried out to answer the two research questions that have been mentioned. The reaction level was carried out to answer the first research question (RQ1), whether interactive online learning with Jago PUEBI had an impact on learning motivation as seen from student interaction and engagement. The aspects of this evaluation will be adopted from the LEAGUÊ framework in Tahir and Wang (2018a) and Nuci et al. (2021). The learning

level evaluation was conducted in response to the second research query (RQ2), which aimed to determine if interactive online learning with Jago PUEBI could influence the knowledge acquisition of students.

Data Collection Procedure

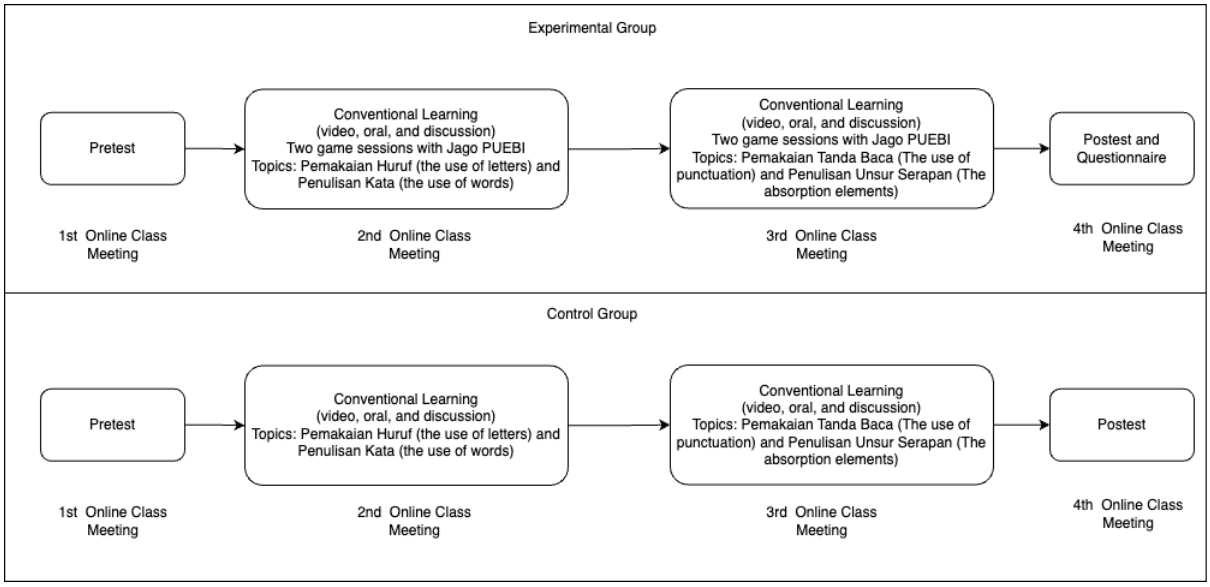
The data collection method used in this research is a quasi-experimental design involving two groups, namely experimental and control, which will receive different treatments, or what is called a nonequivalent control-group design (Leavy, 2017). In quasi-experiments, researchers usually have access to an educational institution to conduct their research, so subjects or participants are not chosen randomly (Leavy, 2017). This experiment was divided into three sessions: a pretest, learning activities, and a posttest. Both the pretest and posttest consisted of 60 questions generated from the question bank. All sessions were held via an online meeting application due to a pandemic situation. During the first session, all students were assigned to complete the pretest via the LMS. To prevent cheating, all students had to turn on their cameras during the test and tell them that the scores were not used as the final scores.

The second session consisted of two main topics, as seen in Table 1. Both groups received conventional online learning modes, such as oral, discussion, and video learning approaches. In contrast to the control group, the experimental group used the Jago PUEBI app during the learning session for each learning topic (see Figure 13).

In the last session, all students were supposed to complete the posttest via LMS. Furthermore, the experimental group was required to fill out a questionnaire regarding the students' perceptions of the app through Google Forms. The data from all sessions was recorded and evaluated to answer the research questions.

Figure 13

Data Collection Procedure



Participants

A purposive sampling method was conducted to select best-fit participants based on specific sample criteria (Robinson, 2014). A total of 260 first-year students from seven faculties of Bandung Institute of Technology who were enrolled in the Indonesian Language: Scientific Writing course participated in this study. The average first-year student is 18 years old; they are students with an excellent academic background and are in the top two highest average scores on the national higher education entrance exam in Indonesia in 2021 (Prastiwi & Ihsan, 2021). Gender differences were not studied, so researchers did not collect gender data from participants. The students were split into two groups: the experimental group (N = 122) and the control group (N = 138). This experiment was carried out in the TTKI class with the assistance of TTKI lecturers in the spring semester of the 2021–2022 academic year during the COVID-19 pandemic lockdown.

Preliminary Data Analysis

Clearance data were required because some students did not participate in all experiment sessions. In this study, outlier data was removed and not processed further in the analysis (Bakker & Wicherts, 2014). Data analysis was carried out in this research using IBM SPSS.

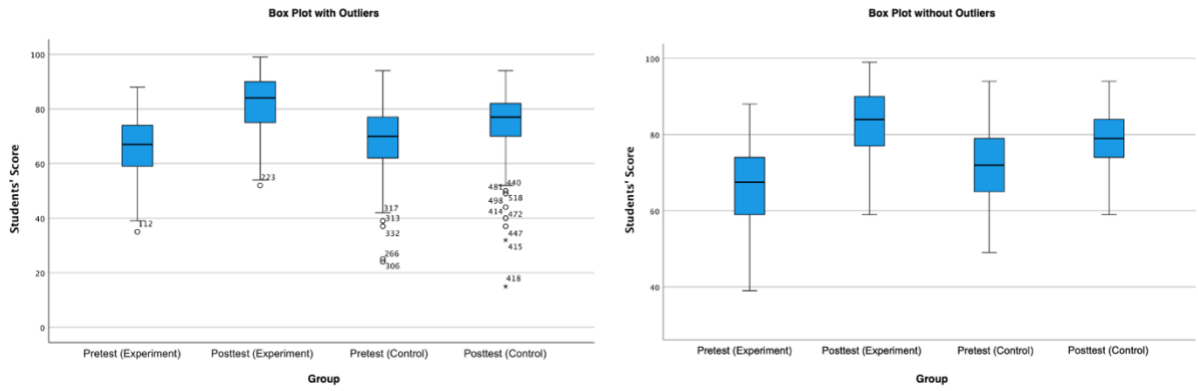
As already mentioned, evaluation level 1 (reaction) was designed to answer RQ1. The questionnaire items were adapted and modified from a previous study using a LEAGUÊ framework (Tahir & Wang, 2018) to assess students' responses to a game-based digital quiz (Nuci et al., 2021). Referring to the prior study, three main dimensions have been identified based on the LEAGUÊ instruments, such as usability, game experience, and interactive teaching and learning. A five-point Likert scale (scale 1 = disagree; scale 5 = agree) of 38 questions was devised to evaluate students' reactions. Participants from the experimental group filled out the questionnaires at the 4th meeting of the Indonesian Language: Scientific Writing lecture or about one week after the intervention was completed. Questionnaires were created and filled out using Google Forms so that participants could fill them out online. This condition becomes a challenge in the data collection process. The data cleaning process was carried out to obtain data from individuals who had participated in the gaming session at least three times. The reason is that not all students who filled out the questionnaire took part in a series of activities in the experimental group that had been carried out because they were not present when the online lecture was conducted. Of the total 177 responses obtained, the identities of the respondents were seen in the log of the quiz sessions. There were 54 people who did not meet the criteria for participating in at least three sessions, so 123 responses would be tested for the validity and reliability, and then descriptive analysis would be carried out. A Pearson product-moment correlation and a Cronbach's alpha were conducted to determine validity and reliability of the data. The result of the validity test showed a strong relationship between all variables ($r > 0.5$). Moreover, the result of Cronbach's alpha was nearly scale 1 ($alpha = 0.964$). The results of the questionnaire were considered valid and reliable to be analyzed. The results of the descriptive analysis of the questionnaire data are explained further in the results section.

As explained, evaluation level 2 (learning) was carried out to answer RQ2. Pretest and posttest score data were compared to determine whether there was an increase in knowledge before and after online learning was carried out using a quiz-based gamified mobile virtual

laboratory and how it compared with conventional online learning. Pretest and posttest scores were collected from both the experimental and control groups. Initially, the experimental group had 184 participants who completed the pretest. Data cleaning was subsequently performed based on specific criteria, retaining only datasets from participants who completed the entire series of activities, including the pretest, at least three gaming sessions, and the posttest. This filtering resulted in 126 datasets that satisfied these criteria. In contrast, the control group had an initial count of 174 participants who completed the pretest. Data cleaning was applied with the criteria of including only datasets from participants who completed both the pretest and posttest, yielding a total of 155 datasets that met these criteria. Next, a normality test was carried out to determine whether the dataset of pretest and posttest scores from the two groups was normally distributed or not. The normality test was carried out using the Kolmogorov-Smirnov method with a significance level of 0.05 (*alpha* = 5%). All data on pretest and posttest scores resulting from the research are below the significance level, meaning that the data is not normally distributed. Furthermore, because the data is not normally distributed, efforts will be made to make the data normally distributed. The method used is to remove outliers. To find outliers, a box plot from the IBM SPSS output will be used. As can be seen in Figure 7, there are several data points identified as outliers. These data points are deleted or discarded with a note; if the data is found in the pretest value, then the posttest value for that data point is also discarded, and vice versa. This procedure applies to all groups (control and experimental). Once the outliers were excluded, there were 122 samples left in the experimental group and 138 in the control group. Subsequently, the second normality test was conducted using the same methodology as the initial normality test to determine if the data followed a normal distribution. As a result, only data from the pretest scores in the control group were normally distributed with a significance level of more than 0.05; other data were not normally distributed. After the second normality test, it was decided that a nonparametric statistical test would be carried out using the Mann-Whitney *U* test. As shown in Figure 14, the distribution of scores and mean from the pretest and posttest did not change much, even though outliers had been removed. So, in nonparametric tests, samples without outliers will be used.

Figure 14

Box Plot to Demonstrate and Compare Students' Scores



Results

Research Question 1 (RQ1)

The focus of the questionnaire was to determine students' perceptions of three categories, namely usability, game experience, and interactive teaching and learning, from

using the Jago PUEBI app. Based on Table 2, the respondents showed a positive attitude towards the questionnaire items in each category, with the largest mean value being 4.47 ± 0.78 for the game experience category, followed by 4.42 ± 0.76 for the interactive teaching and learning category, and 4.32 ± 0.85 for the usability category.

Table 2
Likert Scale Results for Three Categories

Categories	Mean	Std. Deviation	Likert Scale (%)				
			1	2	3	4	5
Game Experience	4.47	0.78	0.54	3.46	11.99	31.57	52.44
Interactive Teaching and Learning	4.42	0.76	0.44	1.55	9.39	33.04	55.58
Usability	4,32	0.85	0.43	2.11	8.89	27.59	60.98

There were four aspects or variables measured in the usability category, including simplicity (2 items), accessibility (4 items), ease (3 items), and efficiency (3 items), for a total of 12 items. The results of descriptive statistics (means and standard deviations) on student responses to the usability category can be seen in Table 3. The largest mean value for this category is 4.73 ± 0.53 for an item in the simplicity aspect related to a simple quiz presentation. Meanwhile, the smallest mean value is 3.44 ± 1.11 for one of the items in the accessibility aspect related to the delay during the quiz.

Table 3
Descriptive Statistics for the Usability Category

Aspect	Statement	Mean	Std. Deviation
Simplicity	Quizzes are presented in a simple way.	4.73	0.53
	The steps needed to answer the quiz are optimal.	4.54	0.70
Accessibility	There is an interface and navigation to access the quiz quickly.	4.39	0.72
	There is no delay during the quiz.	3,44	1.11
	I am comfortable with the navigation and quiz interface within the app.	4.27	0.71
	I can immediately find out the correct answer from the quiz after answering it.	4.11	0.90
Ease	I can operate the application without any problems.	3.92	0.98
	I can interact with the app easily.	4.46	0.68
	The application interface is already user-friendly.	4.69	0.60
Efficiency	The navigation and interaction required to access the quiz are very efficient.	4.50	0.67
	The appearance or interface design of the application is efficient.	4.41	0.76
	The application can run smoothly on the device I use.	4.37	0.87

There were four aspects or variables measured in the game experience category, including engagement (7 items), timeliness (3 items), competition (3 items), and interactivity with the app (2 items), for a total of 15 items. Table 4 shows the results of the questionnaire for the game experience category. The largest mean value is 4.68 ± 0.56 for one item in the engagement aspect related to the effect of points (game element) on motivation to answer questions. Meanwhile, the smallest mean value of 3.97 ± 0.95 isalso achieved by the

engagement aspect in a statement related to the influence of animations and sound effects (game aesthetic) on motivation to answer questions.

Table 4
Descriptive Statistics for the Game Experience Category

Aspect	Statement	Mean	Std. Deviation
Engagement	I felt more comfortable and happier during the quiz.	4.47	0.76
	I feel more involved in learning.	4.52	0.71
	My attention and concentration rise as the quiz progresses.	4.52	0.71
	I feel compelled to commit to being involved in answering every question, and I'm very happy to do so.	4.50	0.73
	This type of quiz game appeals to me since it helps me stay focused and awake while learning.	4.57	0.64
	I feel compelled to answer questions quickly to earn more points.	4.68	0.56
	Sound effects and animations keep me motivated to answer questions.	3.97	0.95
Timeliness	The use of a time limit for answering questions enhances the quiz's excitement and interactivity.	4.46	0.83
	The existence of a time limit triggers the need to answer questions quickly and accurately.	4.42	0.87
	I feel more involved and interested in answering questions with a time limit.	4.36	0.94
Competition	I feel like I'm competing and participating in learning.	4.55	0.79
	Knowing the quiz answer (right or wrong) motivates me to try to answer better (fast and accurate) in the next question to earn more points.	4.58	0.65
	I feel like I'm competing and fighting for the first place on the leaderboard.	4.55	0.69
Interactivity with the app	The answer options are given in appealing colors and can be easily selected as an answer.	4.45	0.73
	The selected answer can be submitted easily.	4.38	0.82

There were three aspects or variables measured in the interactive teaching and learning category, including interactivity between students and lecturers as well as between students and students (2 items), learning (4 items), and assessment and evaluation (5 items), for a total of 11 items. Table 5 shows the results of descriptive statistics for questionnaire responses in the game experience category. The largest mean value is 4.63 for one item on the learning aspect that game-based learning makes learning more interesting. Meanwhile, the smallest mean value of 4.12 is achieved by the assessment and evaluation aspect in a statement related to LMS integration, which made it easier to see the results of quiz games.

Table 5
Descriptive Statistics for the Interactive Teaching and Learning Category

Aspect	Statement	Mean	Std. Deviation
	I feel I can interact with the lecturer during the quiz.	4.16	0.83

Aspect	Statement	Mean	Std. Deviation
Interactivity between students and lecturers as well as between students and students.	I feel I can interact with my fellow students during the quiz.	4.13	0.94
Learning	I feel that the learning method with quiz games is suitable for online learning.	4.51	0.68
	I feel the learning method with quiz games is easier and more fun.	4.55	0.63
	I feel that the learning method with quiz games helps me stay awake while studying and understand the material better.	4.51	0.66
	I feel the learning method with quiz games makes learning more interesting.	4.63	0.55
Assessment and Evaluation	The assessment and evaluation process directly from the quiz game through the app is more effective.	4.40	0.79
	Integration with LMS (Edunex) makes it easy to see the results of quiz games.	4.12	0.92
	I know more about the subject matter through the quiz game method.	4.38	0.73
	I feel challenged to think faster to be able to answer questions during the quiz game.	4.61	0.67
	I feel like learning new things after the answers to the questions in the quiz game are displayed immediately.	4.59	0.63

Research Question 2 (RQ2)

The impact of using a gamified mobile virtual laboratory on learning outcomes in the form of increasing student knowledge can be determined by using pretest and posttest scores. The results of descriptive statistics of students' pretest and posttest scores in Table 6 show the mean value for pretest scores of the control group is greater than the experimental group with a difference of 5.56. Furthermore, using the Mann-Whitney *U* test to see the significance of the difference in the pretest scores of the two groups, the test results can be seen in Table 7, with a value of Asym. Sig. (2-tailed) of <.001. It can be concluded that there is a significant difference between the initial knowledge of Indonesian spelling (EYD) for the experimental and control groups. Meanwhile, the mean value for posttest scores of the experimental group is greater than the control group, with a difference of 5.28. Similarly, the results of the Mann-Whitney *U* test for the posttest scores with the value of Asym. Sig. (2-tailed) of <.001 indicates a significant difference between the posttest scores of the control and experimental groups.

Table 6
Descriptive Statistics of Students' Pretest and Posttest Scores

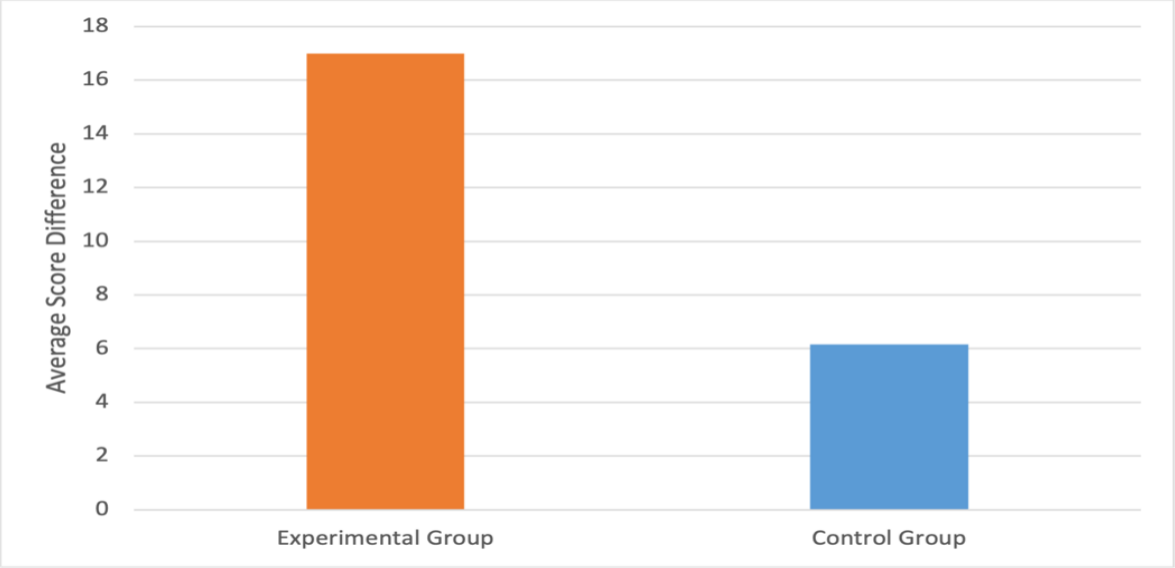
Phase	Group	N	Mean	Std. Deviation	Min.	Max.
Pretest	Control	138	71.50	9.875	49	94
	Experimental	122	65.94	11.384	39	88
Posttest	Control	138	77.66	9.447	59	94
	Experimental	122	82.94	8.729	59	99

Table 7
Mann-Whitney U Test for Students' Pretest and Posttest Scores

	Students' Score (Pretest)	Students' Score (Posttest)
Mann-Whitney *U*	6181.500	5521.500
Wilcoxon *W*	13684.500	15112.500
Z	-3.699	-4.795
Asym. Sig. (2-tailed)	<.001	<.001

As shown in Table 6, the mean difference between the pretest and posttest scores for the experimental group is 82.94 – 65.94 = 17, while the mean difference between the pretest and posttest scores for the control group is 77.66 – 71.50 = 6.16. For more details, the comparison of the gains of the experimental and control groups can be seen in Figure 15.

Figure 15
Comparison in Mean Value for Pretest and Posttest Scores Between the Two Groups



Discussion

The results of the first research question indicate that students' perceptions of gamified learning using the app were very positive. The experience of playing games makes students feel more involved or engaged, more comfortable and happier, stay focused and awake, increase concentration and attention, became competitive, and became more motivated in learning. Furthermore, with gamified learning, which promotes interactive learning, students feel more connected to their fellow students and lecturers, so they feel that this learning method is suitable for online learning conditions that have interaction challenges (Adnan, 2020). In addition, with the use of quiz games, they can learn more about the subject matter and are able to evaluate and assess their knowledge more effectively. The positive attitude of students towards gamified learning is in line with the findings of previous studies conducted by Eltahir et al. (2021), Nuci et al. (2021), Bicen & Kocakoyun (2018), Phuong (2020), and Zhumasheva et al. (2022). In contrast to previous studies, which mostly used existing platforms such as Kahoot!, this study also succeeded in building a learning game in the form of a virtual laboratory within an existing learning management system (LMS) in a higher education institution.

The results of the second research question show that the use of a gamified mobile virtual laboratory in online learning has a positive impact on student learning outcomes. At first, the students from the control group had better prior knowledge than the students from the experimental group based on the significant difference in the results of the pretest. After that, they attended lectures according to the experimental design as shown in Fig 2. The posttest results showed a significant difference between the two groups; both groups showed improvement after the experiment, but the experimental group was 2.76 times better than the control group. this finding is in line with Eltahir et al. (2021) that using gamified learning can improve learning outcomes in Arabic grammar courses, it was proven that the mean score of the students in the experimental group is 1.8 times better than that of the control group. In addition, the study conducted by Nuci et al. (2021) and Bawa (2019) found similar results that the use of gamified learning can improve learning outcomes or performances in Human Computer Interaction courses and Introduction to Business courses.

However, there are limitations that might affect the validity of the research results. First, since the process of collecting pretest and posttest data for RQ2 was carried out online with minimal supervision, the students might cheat, even though it has been announced that these scores would not be used for the final scores. More adequate proctoring software is recommended in future research to help maintain the integrity of the pretest and posttest processes conducted online (Purpura et al., 2021). Second, this study used 38 questionnaire items with a 5-point Likert scale to answer RQ1, so the results were very dependent on the choice of students who had subjectivity when choosing them. In future research, qualitative data can be collected and analyzed through techniques such as focus group discussions and thematic analysis to better study how students perceive the use of proposed technology in learning (Johri & Hingle, 2023). Apart from that, studying differences in perceptions based on student background, such as gender, is also interesting for further research.

Based on the results of RQ2, the user's perception of the accessibility aspect of the item "There is no delay during the quiz." is the smallest. The direction for further research is how to make this learning game more accessible in various conditions so that there are no more delays felt by some students. Furthermore, in this study, the use of the learning game focused on synchronous classroom learning. The future research should combine the synchronous and asynchronous learning outside the classroom.

Conclusion

With online learning or distance learning becoming the new normal, educational institutions need solutions that can help increase the effectiveness of such learning. The development and the use of a learning game in this study is an effort to help higher education institutions provide a fun and engaging learning environment to increase motivation and learning outcomes. This study aimed to evaluate the gamified mobile virtual laboratory that has been developed specifically for Indonesian language courses at a higher education institution. The first evaluation was to find out students' perceptions of usability, game experience, and interactive learning with the learning game. The second evaluation was to determine the effect on student learning outcomes. Based on the results of the first evaluation, overall students were satisfied with the usability of learning games. They also felt that the experience of playing games in learning could make them happier, more focused, engaged, and motivated. In addition, they also feel that they can interact with their lecturers and fellow students while playing games. The results of the second evaluation also showed that the students in the experimental group who had the experience of playing the learning game had higher learning outcomes than the control group based on the comparison of the gains from the

pretest and posttest scores. These results are evidence that the learning game can be a suitable tool to increase the effectiveness of Indonesian language learning, especially in online learning mode. Nonetheless, it is important to note that these findings should not be generalized broadly, as they pertain solely to a single higher education institution. Therefore, additional research is required to assess the effects of implementing this technology on a more diverse user population, encompassing various age groups and individuals from diverse educational backgrounds and institutions.

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