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Integrating Gamification Elements into a Personalized Cognitive Mobile-Learning LINE Bot

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Abstract

In recent years, chatbots gains widespread popularity across various industries, and LINE becomes an indispensable and widely utilized application. Human beings acquire knowledge through cognitive learning. Asynchronous digital drills and practice learning systems that require students to practice questions repeatedly can bore students and lack online monitoring by a teacher. In this study, the cognitive mobile-learning LINE bot provides digital drill and practice learning functions, enabling students to read questions and their answers from a Q&A database, take a postlearning self-test on these questions, and practice questions they originally answered incorrectly. Moreover, learners can ask open-ended questions. The LINE bot is used to substitute for a teacher in one-on-one synchronous interactive learning, and the post-hoc analyses of the interactions between the LINE bot and each student are performed and provided to teachers on time, enabling them to offer counseling and assistance as appropriate.

Keywords: gamification, personalized learning, mobile-learning LINE bot, Class B technician program for computer hardware fabrication

1. Introduction

In recent years, chatbots have gained widespread popularity across various industries. According to market research by Insider Intelligence, 40% of global users prefer to receive customer service through chatbots [1]. Statistically, the percentage of individuals using mobile devices to access the internet in Taiwan has risen from 1% in 2010 to 82.1% in 2020 [2]. On average, people spend a quarter of their daily time online [3]. Among the most used mobile applications, LINE accounts for 95.7%, Facebook for 90.8%, Instagram for 70.6%, and Messenger for 68.5%, with LINE being regarded as an indispensable and widely utilized application [4]. LINE bot, a type of chatbot based on the LINE platform, allows users to engage in conversations with the bot. It provides personalized responses and services based on user needs and commands. LINE bot enables developers to create and operate their own chatbots, facilitating interactions with LINE users on the platform. For developers, LINE bot offers a comprehensive set of APIs (Application Programming Interface) to handle various types of user messages, including text and images, enabling the customization of LINE bots to build and deploy their customized LINE bots [5]. In recent years, chatbots have demonstrated potential and effectiveness education. Compared to traditional teaching methods, using chatbots for learning has been shown to significantly improve learning achievements and motivation. It also enhances students' confidence and enthusiasm for learning, receiving positive feedback and acceptance from learners [6]. Through intelligent design and personalized interaction, chatbots make learning more enjoyable and accessible for learners, providing timely guidance and feedback. This significantly enhances learning achievements and motivation by providing tailored assistance to individual learners [7].

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In the educational objectives of vocational schools, there is an emphasis on cultivating the elementary level of technical talents in vocational senior high schools, the intermediate level of technical talents in junior colleges, and the advanced level of technical talents in universities of science and technology [8]. Skill certification has been one of the driving forces behind the development of modern industry and commerce. Developed countries maintaining a leading edge in the industrial sector is closely related to the establishment of a vocational certification system. As Taiwan's industrial structure has evolved towards high-tech development, and various industries have become increasingly specialized, moving towards a vocational certification system is an inevitable trend. Article 10 of the regulations on technical skills testing and certification for technicians reveals that passing both the subject and practical tests for the same class and level of technical skills is considered as passing the certification [9]. Any type and level of technician's skill certification includes both subject and practical tests.

The subject test is conducted using a range-based question bank, while the practical test is based on the domain of a specific profession. Reference materials for the test are publicly available for candidates to study and practice before the examination [9]. According to statistics from the Skill Evaluation Center of the Bureau of Employment and Vocational Training, Ministry of Labor, the pass rates for skill certification are as follows: Class A - 14%, Class B - 41%, and Class C - 68% [10]. It can be observed that the pass rates are significantly correlated with the certification levels. However, to improve the overall pass rates for skill certification, both subject and practical test pass rates must be increased. In vocational schools or vocational training institutions, skill certification training courses mainly focus on practical instruction. This is because the practical test involves specialized skills that require professional equipment or tools and usually necessitates specialized training facilities for practice.

Human beings can acquire knowledge through cognitive learning. Many systems for digital cognitive learning have been developed [11]. Most such systems primarily implement asynchronous online drill and practice learning systems with conventional cognitive question databases for learning. Such systems provide real-time feedback and enable students to acquire knowledge through repeated practice. Therefore, these systems are frequently used in classrooms. However, asynchronous online learning environments often lack teacher monitoring and are considered dull by students; these factors do not spark learning motivation and result in poor learning effectiveness. Methods of overcoming this problem should be explored to produce systems that can substitute for teachers and help students increase their learning autonomy, motivation, and cognition.

In the 1970s, researchers believed that behaviorism could explain how cognitive abilities, such as knowledge and memory [12]. Cognitive development is the first stage of acquiring knowledge about the world. Through repeatedly experiencing cognitive stimuli, responding, and acquiring feedback, humans can continually increase their knowledge. Digital drill and practice learning is a type of digital learning that incorporates behaviorism; it is commonly used to help students develop their cognitive abilities by using question and answer (Q&A) databases. Through repeatedly experiencing stimuli and responding a stimulus–response (SR) association model can be formed. Providing feedback in an SR–feedback (SRF) model can further reinforce the connection between stimuli and responses. Fig. 1 presents a graphic depicting this process. Positive reinforcement is provided through praises and rewards, and punishment is administered to inhibit incorrect behavioral responses. Immediate feedback is critical; the effect of feedback is greater if it is closer to the response. This phenomenon is known as the law of effect. Repeated practice is strongly encouraged to help students attain subject mastery.The goal of this practice is to strengthen the S-R association.

The design of the curriculum allows students to repeatedly practice the course content, which eventually enables them to rapidly produce the correct responses (in accordance with the law of exercise). In the digital drill and practice learning system, each question acts as a stimulus, and the selected answer is the response. Feedback for correct or incorrect answers, respectively, is given by adjusting the student’s score (with the law of effect). The system enables learners to repeatedly practice until reaching mastery. The digital drill and practice learning method was developed to accelerate the SRF cognitive process, but

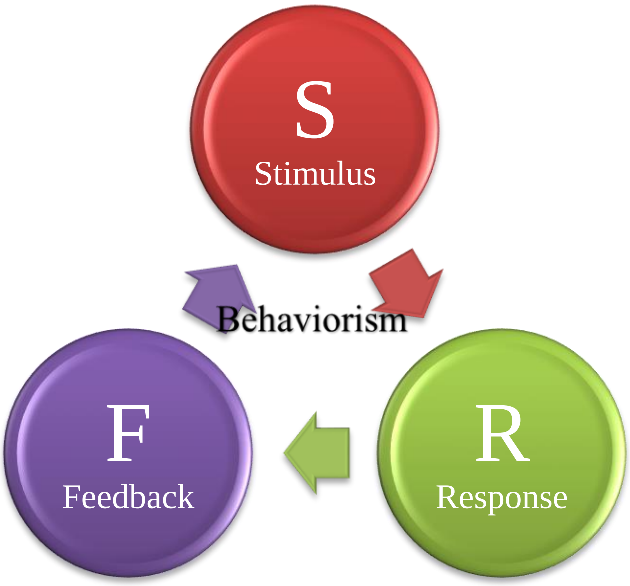


Fig. 1 SRF model of behaviorism

the emphasis on continual learning to achieve mastery is repetitive and dull. The method does not increase learners' learning motivation or self-learning drive [13].

The prevalence of cloud technology has resulted in the wide applications of personalized services [14]. During out-of-class learning on online platforms, students can select personalized activities to progress. The difficulty of these activities increases gradually. A personalized report is typically provided to each student to help them understand their learning progress. As students' progress gradually increases, they may obtain satisfaction and have increased motivation to participate in accordance with the goal of personalized learning, which is to improve the learning experience and learner results [15]. The stimuli and design of the learning environment directly affect student learning. In a digital learning environment, the active attitude of students greatly affects their learning effectiveness, whereas a dull or lengthy learning process impairs student learning attitude [16].

Mobile learning (M-learning), also called ubiquitous learning, refers to a context-aware learning environment that can be accessed through mobile devices and the Internet [17]. M-learning features three essential elements: mobile devices, communication infrastructure, and learning activity modules [18]. The core characteristics of M-learning are ubiquity, portability, personalization, interactivity, cooperativeness, information immediacy, and mixture. M-learning improves traditional distance education by enabling students to learn anywhere and at any time [19].

Prensky claimed that people born after 1975 were the game generation (or G generation). Due to the joy brought by game-based learning, it can increase learning motivation more than the dull atmosphere of traditional classrooms can; it is therefore also called joyful e-learning. Game-based e-learning is expected to become the main method of learning in the 21st century. It replaces the passive learning method of traditional education with active participation in learning activities [20]. In game-based learning, students not only play but also discuss, research, and imagine the games. Incorporating digital games into courses can increase intrinsic motivation to learn, thereby prompting learners to commit more time and energy to learning [21]. The game-based learning model is divided into three stages: input, process, and outcome (Fig. 2). During the game loop, students feel joy as their performance gradually improves. They are therefore willing to continue learning in the game loop, eventually resulting in a flow experience, which is a state of intense concentration in which an individual is unaware of the flow of time. The flow experience is associated with high levels of excitement and fulfillment [22]. Many studies have indicated that game-based e-learning improves student learning effectiveness and results in substantially higher learning motivation than traditional learning does [23].

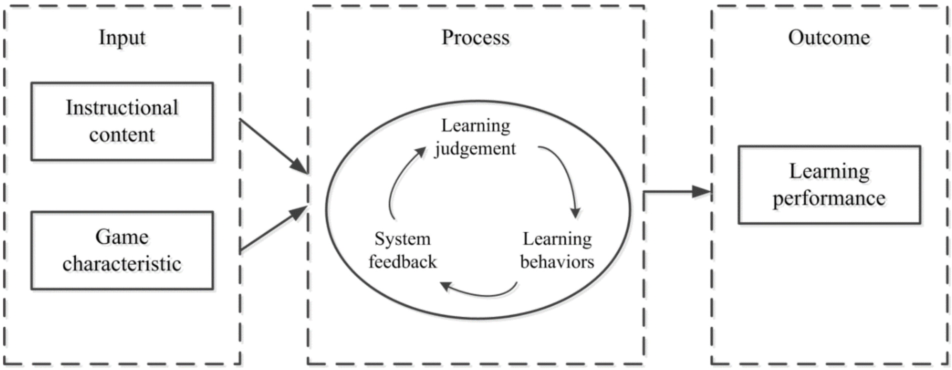


Fig. 2 Game-based learning mode [22]

Gamification is somewhat similar to game-based learning, but gamification emphasizes excitement during the learning process. In gamification, game elements that are fun and inspire participation are implemented in real-world activities. The process is also called human-focused design; the goals are maximizing user motivation, perception, and participation. One gamification architecture is Octalysis (Fig. 3). Octalysis has a human-focused game design and is represented as an octagonal shaped, with each edge representing one core drive; the edges are epic meaning and calling, development and accomplishment, empowerment of creativity and feedback, ownership and possession, social influence and relatedness, scarcity and impatience, unpredictability and curiosity, and loss and avoidance [24].

The architecture is frequently used to optimize people's feelings, motivation, and involvement (participation) [24]. The most widely applied gamification elements include points, badges, and leaderboards; these are sufficient to encourage competition in traditional teaching environments or systems [25]. PeerWise is an after-class online learning system that enables students to develop questions independently. The system uses badges to effectively increase student participation. The gamification of the system increased student enthusiasm to use it, and the system was demonstrated to be effective for learning [26]. Applying features of games, such as points, virtual coins, and levels, in another context such as the educational environment and social interaction environment could improve learning outcomes [27]. Gamification can effectively increase learning intensity and improve learning outcomes [28] and is highly effective in enhancing student participation and immersion [29].

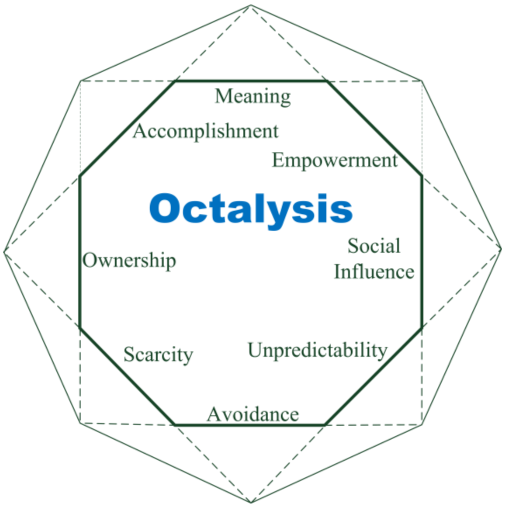


Fig. 3 Octalysis gamification model [24]

Traditional teaching must occur at a fixed place and time, and the emphasis on repeated practice to achieve mastery in asynchronous digital drill and practice learning is also boring for students. Additionally, without teacher monitoring, students' intrinsic learning motivation may not be sparked. To overcome these problems, a quasi-synchronous M-learning system that transcends traditional teaching by applying Q&A databases was produced in this study. The system is called Class B Mobile-learning LINE bot (hereinafter referred to as the LINE bot). The Q&A database was based on data for the Class B Computer

Hardware Fabrication test provided by the Skill Evaluation Center of Workforce Development Agency, Ministry of Labor. The personalized system includes Q&A database learning, postlearning self-tests, and gamification learning mechanisms, and provides answers to open-ended student questions; hence, it retains the advantages of traditional education for student learning. The proposed method empowers a LINE bot to assume the role of a teacher, facilitating student learning anytime and anywhere. The system incorporated gamification elements for mobile learning. Moreover, post-hoc analyses of the interactions between the LINE bot and each student were provided to teachers to inform them of student learning progress in a timely manner, enabling them to offer counseling and assistance as appropriate.

2. System Design and System Implementation

The research framework and system implementation method of this study were based on the guidelines for research on information systems. The system was developed and experimentally validated with the science research guidelines designed by Hevner et al. (Fig. 4) [30]. Explanation is provided for the system design and the proposed knowledge base recommendation algorithm.

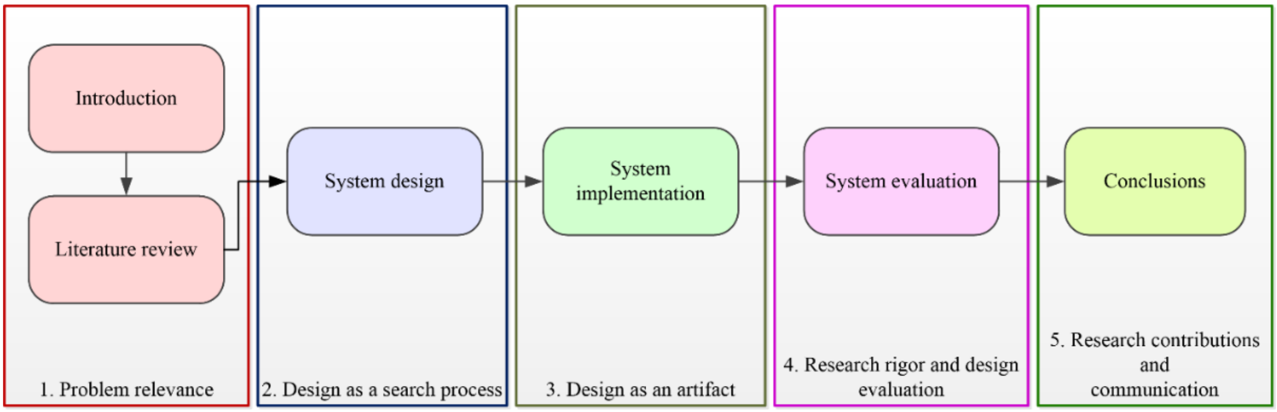
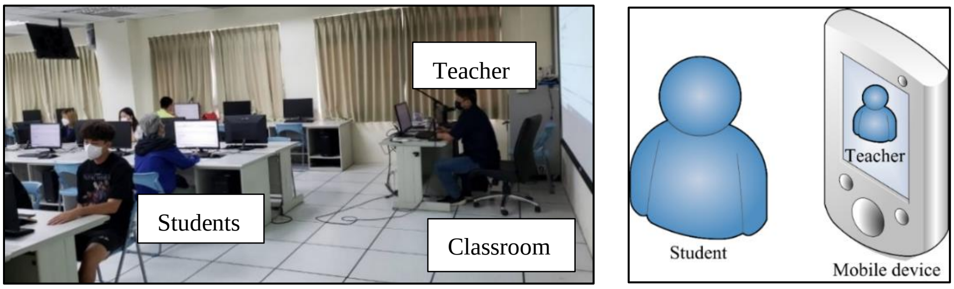


Fig. 4 Design science research process of the system [30]

2.1. System design

In traditional teaching, instruction typically occurs at a fixed time and location (Fig. 5(a)). Only the teacher prepares the course content; lecturing, questioning, and testing students requires great effort from teachers.

In this study, an M-learning method (Fig. 5(b)) was developed to replace the traditional classroom with multiple students, enabling personalized learning anywhere and at any time. The teacher was replaced with the LINE bot, which provided each student with personalized learning. The proposed method increased learning flexibility, autonomy, and personalization.



(a) Traditional teaching (b) M-learning method

Fig. 5 Comparison between traditional teaching and the proposed M-learning method

When students engaged in learning through mobile devices, the LINE bot interacted with the students by repeatedly providing questions and answers for the students to read. The system also provided self-tests and offered repeated practice on incorrectly answered questions to help students achieve mastery. In addition, gamification was implemented by enabling students to accumulate points and answer questions competitively to avoid boredom during learning, increasing their learning motivation and self-learning motivation. The LINE bot extracted data from the student mobile devices; these data were stored on a Google Apps Script (GAS) server, which also implemented scripts. The learning behavior data stored on the GAS server were analyzed and provided to teachers to offer real-time information regarding student interactions with the LINE bot, enabling the teachers to provide timely assistance and counseling. The system operation is depicted in Fig. 6.

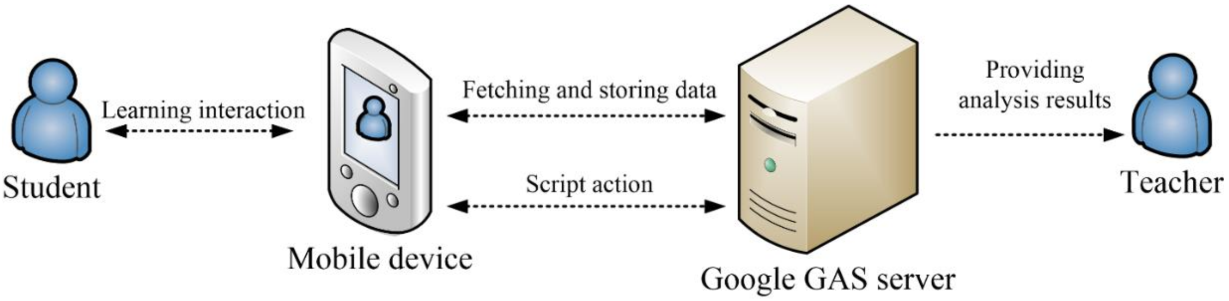


Fig. 6 System operating mode

The M-learning system interface was designed based on the aforementioned personalized learning context and with a focus on user convenience. The system framework comprises three blocks (Fig. 7) that contained the name of the virtual teacher, interactive learning area, and menu.

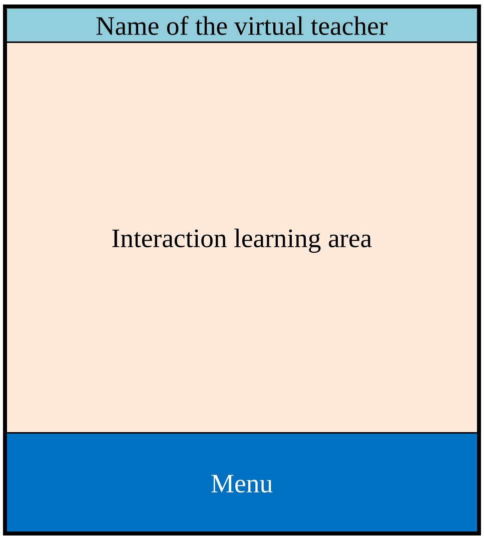


Fig. 7 System interface

The Q&A database learning section provides personalized learning tasks, including reading questions with their answers, self-tests, and practice for incorrectly answered questions; it also allowed students to check their reading completion rate. In the gamified learning section, students could participate in competitive question answering and accumulate points. The open-ended question feature enabled students to ask the virtual teacher (the LINE bot) any question. A recommendation algorithm was then used to provide a relevant answer from a knowledge base. The system architecture is depicted in Fig. 8.

In Q&A database learning, the students first read all of the questions. Random questions were then displayed to ensure that the students had read all the questions. Students were first required to read a question before it was included in a quiz to ensure that they engaged in cognitive learning before practicing, avoiding guessing. Students could repeatedly practice the incorrectly answered questions until they achieved mastery.

In gamified learning, students were awarded 1 point for every 100 questions read and for every 35 questions answered correctly in either the self-test or practice test for incorrectly answered questions. For every 6 points, 1 was added to the student’s total score. Bonus question answering sessions were held intermittently to increase fun in the learning process and enhance student self-learning motivation.

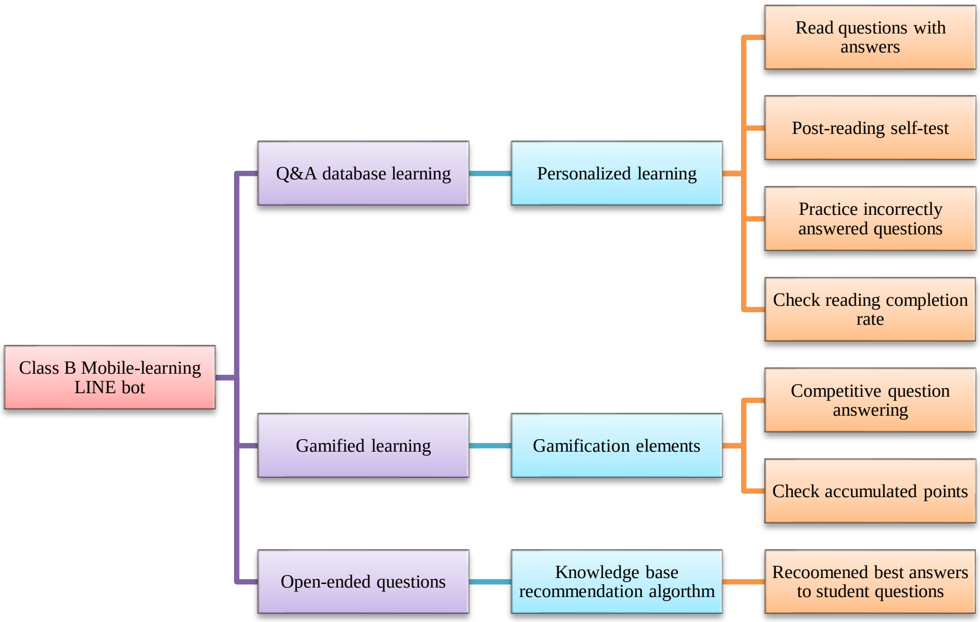


Fig. 8 System architecture

2.2. *Knowledge base recommendation algorithm*

A recommendation algorithm was used to identify answers in a knowledge base to respond to open-ended student questions. The process was as follows: First, a knowledge base was established that included a primary key, content, and fields for five keywords.

When a student asked the LINE bot a question, the system performed a fuzzy comparison between the question and the keywords of the knowledge base (as shown in Fig. 9). If a keyword matched the question, its weight was set to 1; otherwise, it was 0.

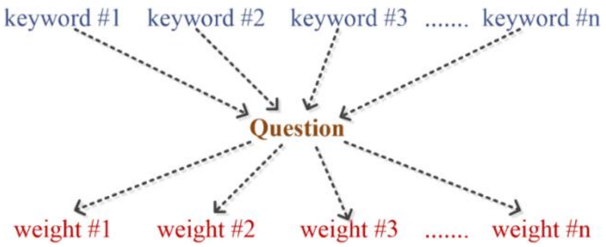


Fig. 9 Knowledge base recommendation comparison

Then, (1) (with n = 5) was used to tally the weights of all keywords for each primary key as follows.

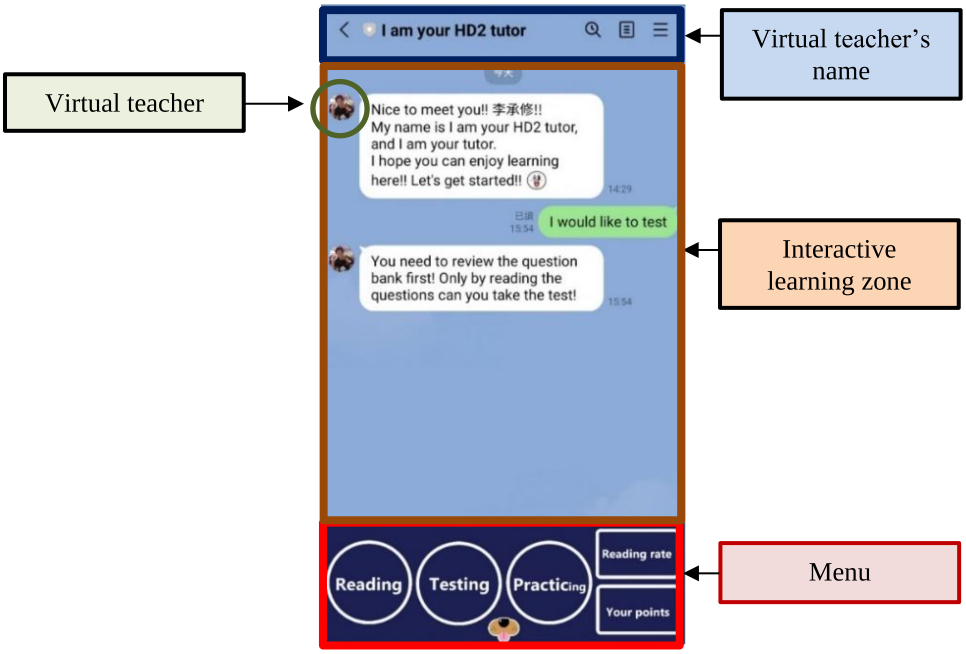
$$weights=\sum_{i=1}^{n} weight\#i \tag{1}$$

Finally, the weights of all primary keys were ranked, and the content associated with the highest weights was provided as the recommended answer.

2.3. *System implementation*

LINE is a commonly used social media application; hence, the M-learning system was developed as a LINE bot to enable its widespread use. The LINE bot was developed on the GAS platform and the LINE developers platform provided by LINE Corporation.

An image of a conversation with the LINE bot is depicted in Fig. 10. The system was developed based on the system interface design in Fig. 7.



I am your HD2 tutor

今天

Nice to meet you!! 李承修!!
My name is I am your HD2 tutor, and I am your tutor.
I hope you can enjoy learning here!! Let's get started!! 14:29

已讀 15:54 I would like to test

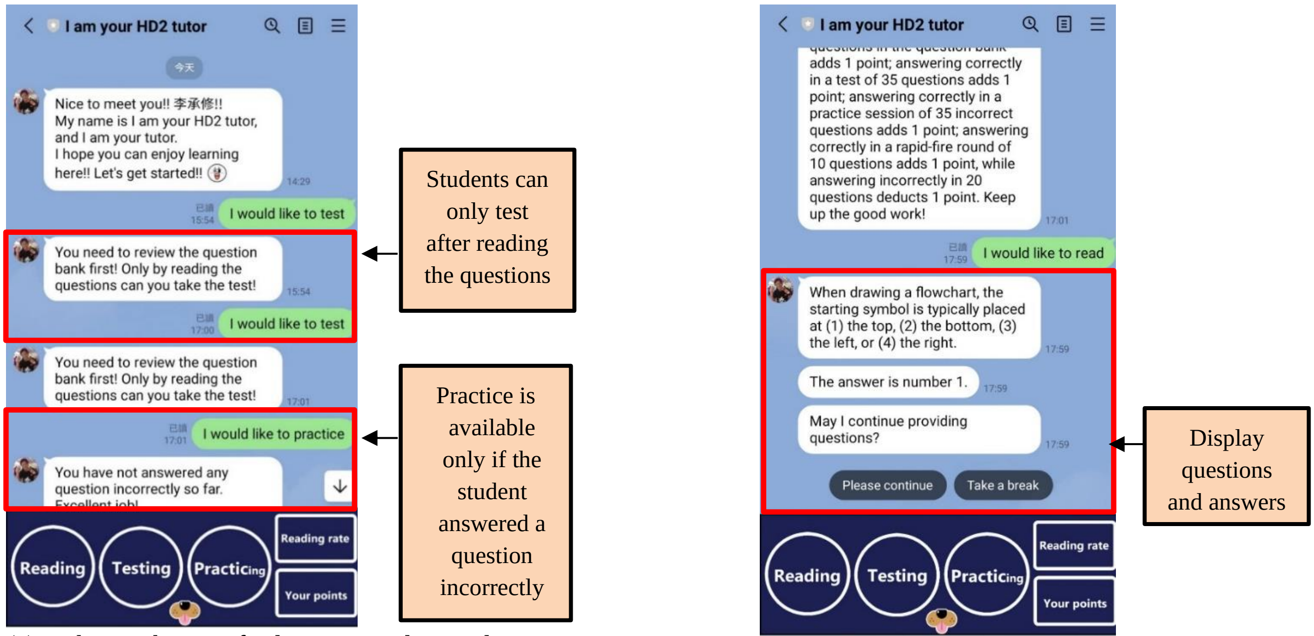
You need to review the question bank first! Only by reading the questions can you take the test! 15:54

Fig. 10 System implementation

Tests were conducted to confirm that the M-learning system functions (Q&A database learning mechanism, gamification learning, and open-ended questions) were in accordance with the requirements of the S-R association model, law of proximity, law of effect, and law of exercise.

(1) Q&A database learning mechanism

The LINE bot guided the students through reading each question and then provided random questions for the students to answer. The students could begin testing only after reading questions, ensuring that they practice only after cognitive learning and do not guess. Students could repeatedly practice on questions that they answered incorrectly until they mastered the content. This process is depicted in Figs. 11(a)-(g). The figure indicates that the system provides a stimulus and response with the SR association model.



I am your HD2 tutor

今天

Nice to meet you!! 李承修!!
My name is I am your HD2 tutor, and I am your tutor.
I hope you can enjoy learning here!! Let's get started!! 14:29

已讀 15:54 I would like to test

You need to review the question bank first! Only by reading the questions can you take the test! 15:54

已讀 17:00 I would like to test

You need to review the question bank first! Only by reading the questions can you take the test! 17:01

已讀 17:01 I would like to practice

You have not answered any question incorrectly so far. Excellent job!

I am your HD2 tutor

adds 1 point; answering correctly in a test of 35 questions adds 1 point; answering correctly in a practice session of 35 incorrect questions adds 1 point; answering correctly in a rapid-fire round of 10 questions adds 1 point, while answering incorrectly in 20 questions deducts 1 point. Keep up the good work! 17:01

已讀 17:59 I would like to read

When drawing a flowchart, the starting symbol is typically placed at (1) the top, (2) the bottom, (3) the left, or (4) the right. 17:59

The answer is number 1. 17:59

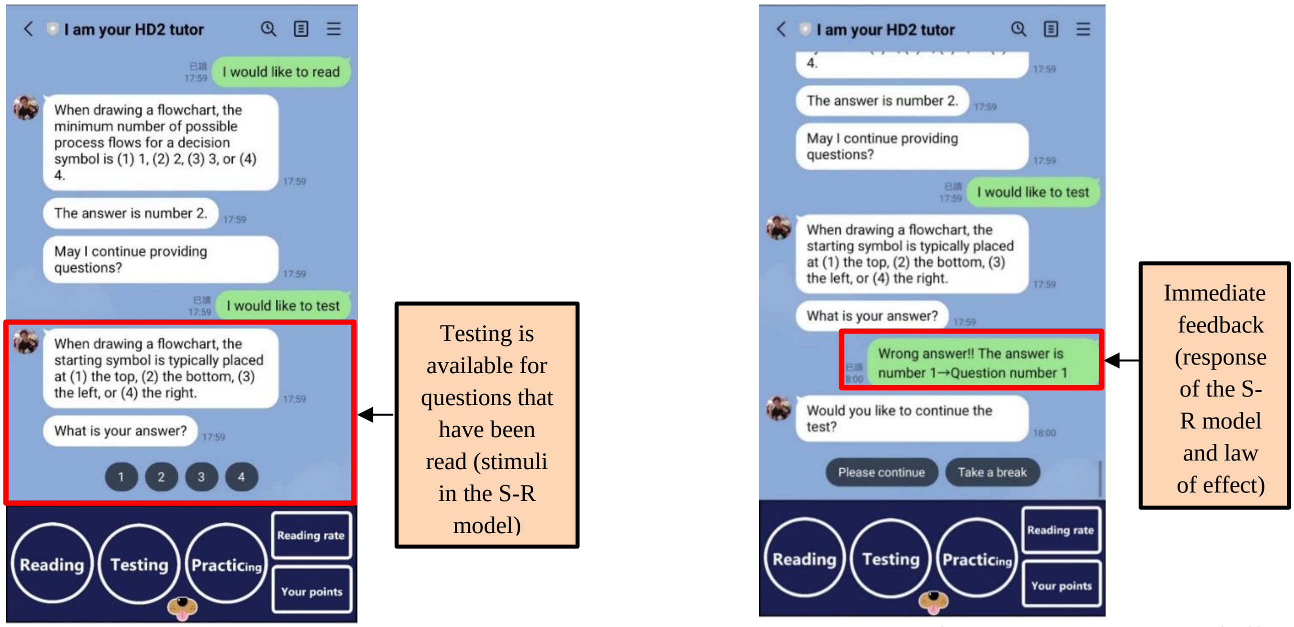
May I continue providing questions? 17:59

Please continue | Take a break

(a) The mechanism for limiting reading and practicing incorrect questions

(b) Display questions based on the reading mechanism

Fig. 11 Q&A database learning



I would like to read

When drawing a flowchart, the minimum number of possible process flows for a decision symbol is (1) 1, (2) 2, (3) 3, or (4) 4.

The answer is number 2.

May I continue providing questions?

I would like to test

When drawing a flowchart, the starting symbol is typically placed at (1) the top, (2) the bottom, (3) the left, or (4) the right.

What is your answer?

Testing is available for questions that have been read (stimuli in the S-R model)

(c) Stimuli in the S-R model

4.

The answer is number 2.

May I continue providing questions?

I would like to test

When drawing a flowchart, the starting symbol is typically placed at (1) the top, (2) the bottom, (3) the left, or (4) the right.

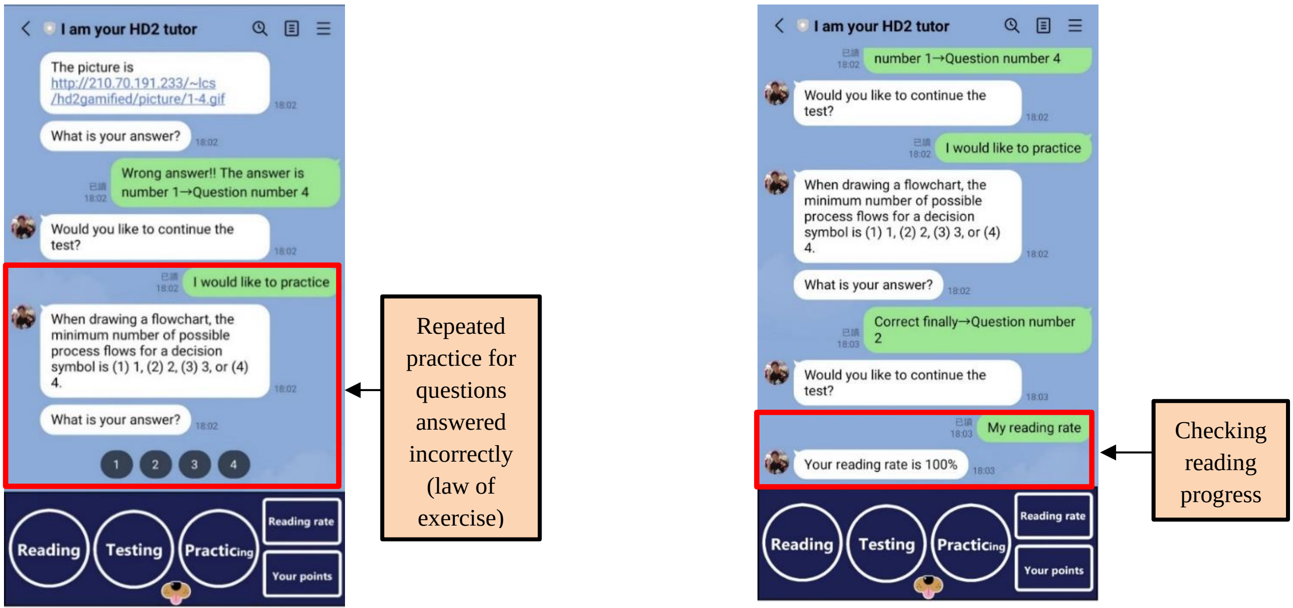
What is your answer?

Wrong answer!! The answer is number 1→Question number 1

Would you like to continue the test?

Immediate feedback (response of the S-R model and law of effect)

(d) Response of the S-R model and law of effect



The picture is http://210.70.191.233/~lcs/hd2gamified/picture/1-4.gif

What is your answer?

Wrong answer!! The answer is number 1→Question number 4

Would you like to continue the test?

I would like to practice

When drawing a flowchart, the minimum number of possible process flows for a decision symbol is (1) 1, (2) 2, (3) 3, or (4) 4.

What is your answer?

Repeated practice for questions answered incorrectly (law of exercise)

(e) Law of exercise

number 1→Question number 4

Would you like to continue the test?

I would like to practice

When drawing a flowchart, the minimum number of possible process flows for a decision symbol is (1) 1, (2) 2, (3) 3, or (4) 4.

What is your answer?

Correct finally→Question number 2

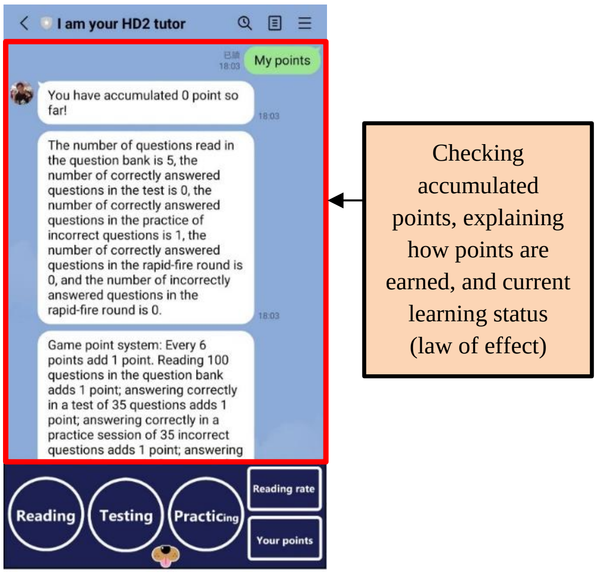
Would you like to continue the test?

My reading rate

Your reading rate is 100%

Checking reading progress

(f)Checking reading progress



My points

You have accumulated 0 point so far!

The number of questions read in the question bank is 5, the number of correctly answered questions in the test is 0, the number of correctly answered questions in the practice of incorrect questions is 1, the number of correctly answered questions in the rapid-fire round is 0, and the number of incorrectly answered questions in the rapid-fire round is 0.

Game point system: Every 6 points add 1 point. Reading 100 questions in the question bank adds 1 point; answering correctly in a test of 35 questions adds 1 point; answering correctly in a practice session of 35 incorrect questions adds 1 point; answering

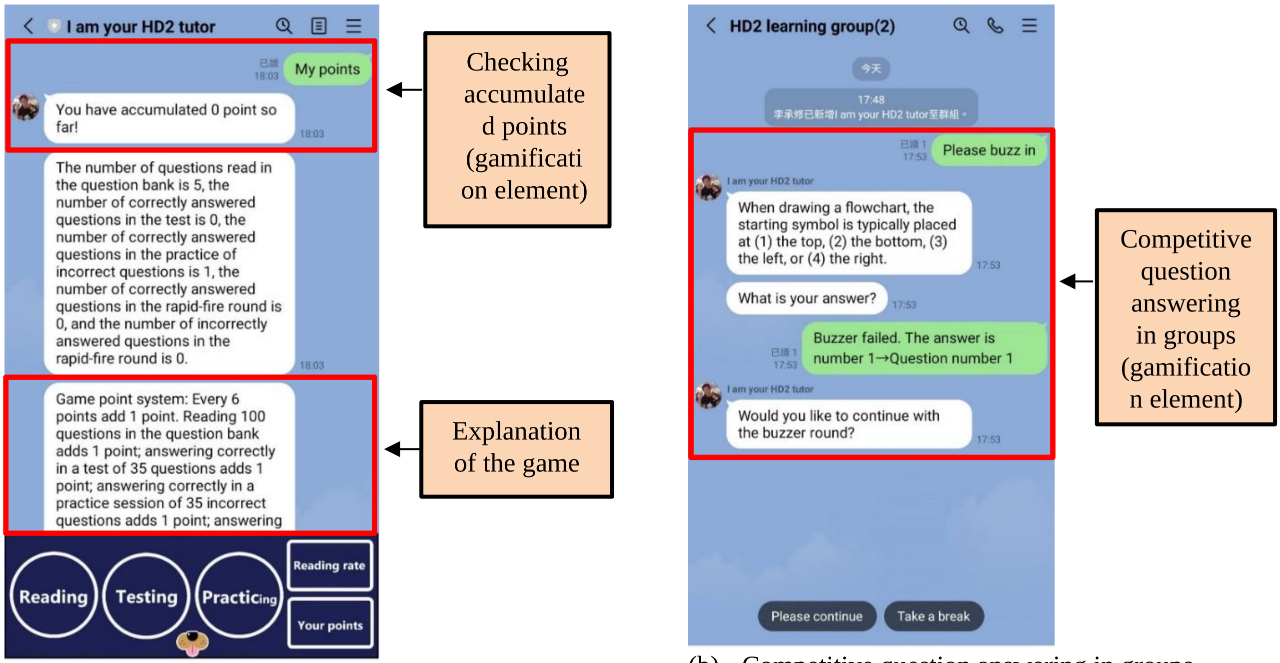
Checking accumulated points, explaining how points are earned, and current learning status (law of effect)

(g) Law of effect

Fig. 11 Q&A database learning(continued)

(2) Gamified learning

In gamified learning, students were awarded 1 point for each 100 questions read and for every 35 questions answered correctly in either the self-test or practice test for incorrectly answered questions. For every 6 points, 1 was added to the student's total score. Bonus question answering sessions were held intermittently to increase fun in the learning process and enhance student self-learning motivation. Fig. 12(a) presents a learner checking their accumulated points, and Fig. 12(b) displays the LINE bot starting a competitive question answering session.



You have accumulated 0 point so far!

The number of questions read in the question bank is 5, the number of correctly answered questions in the test is 0, the number of correctly answered questions in the practice of incorrect questions is 1, the number of correctly answered questions in the rapid-fire round is 0, and the number of incorrectly answered questions in the rapid-fire round is 0.

Game point system: Every 6 points add 1 point. Reading 100 questions in the question bank adds 1 point; answering correctly in a test of 35 questions adds 1 point; answering correctly in a practice session of 35 incorrect questions adds 1 point; answering

Checking accumulated points (gamification element)

Explanation of the game

When drawing a flowchart, the starting symbol is typically placed at (1) the top, (2) the bottom, (3) the left, or (4) the right.

What is your answer?

Buzzer failed. The answer is number 1→Question number 1

Would you like to continue with the buzzer round?

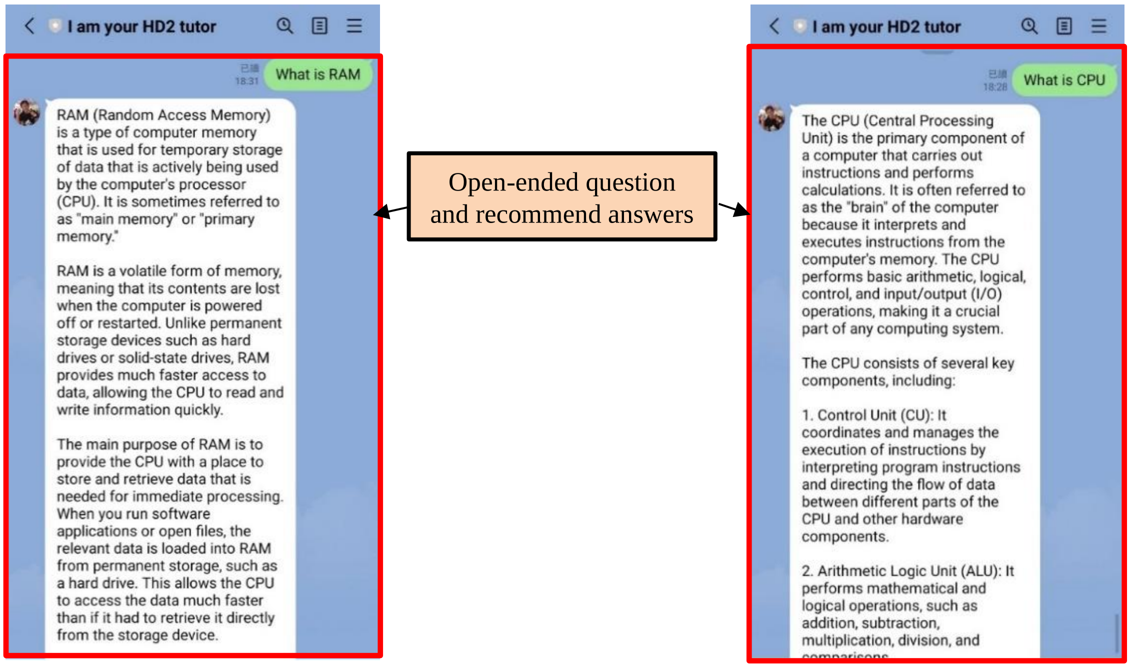
Competitive question answering in groups (gamification element)

(a) Checking accumulated points (b) Competitive question answering in groups

Fig. 12 Gamification mechanism

(3) Open-ended questions

If a student does not understand a question, they can ask a question to the LINE bot, which provides an answer with the knowledge base recommendation algorithm (Fig. 13).



RAM (Random Access Memory) is a type of computer memory that is used for temporary storage of data that is actively being used by the computer's processor (CPU). It is sometimes referred to as "main memory" or "primary memory."

RAM is a volatile form of memory, meaning that its contents are lost when the computer is powered off or restarted. Unlike permanent storage devices such as hard drives or solid-state drives, RAM provides much faster access to data, allowing the CPU to read and write information quickly.

The main purpose of RAM is to provide the CPU with a place to store and retrieve data that is needed for immediate processing. When you run software applications or open files, the relevant data is loaded into RAM from permanent storage, such as a hard drive. This allows the CPU to access the data much faster than if it had to retrieve it directly from the storage device.

Open-ended question and recommend answers

The CPU (Central Processing Unit) is the primary component of a computer that carries out instructions and performs calculations. It is often referred to as the "brain" of the computer because it interprets and executes instructions from the computer's memory. The CPU performs basic arithmetic, logical, control, and input/output (I/O) operations, making it a crucial part of any computing system.

The CPU consists of several key components, including:

1. Control Unit (CU): It coordinates and manages the execution of instructions by interpreting program instructions and directing the flow of data between different parts of the CPU and other hardware components.

2. Arithmetic Logic Unit (ALU): It performs mathematical and logical operations, such as addition, subtraction, multiplication, division, and comparisons.

Fig. 13 Open-ended question system

3. Design and Analysis of the System Experiment

During the system experiment, all participants engaged in self-learning through a LINE bot incorporating gamified elements within the context of the class B computer hardware fabrication subject in mobile learning. After an interaction with a student, the LINE bot uploaded relevant data to the Google GAS server to provide charts to teachers regarding the student's learning status for the question reading, self-test, question practice, and question competition tasks. These data were used by the teachers to determine whether to provide counseling.

3.1. Experiment planning

(1) Experiment duration: A teaching experiment was conducted through self-study using the LINE bot between July 2 and September 2, 2023.

(2) Research tool: The study adopted the LINE bot to upload relevant data and the Google GAS server to generate charts regarding the student's learning status.

(3) Participants: A total of 10 students enrolled in the Level B computer hardware fabrication course in the 2023 academic year participated in this study.

3.2. Analysis of the experimental results

This study analyzes the results of self-learning conducted by the participants through a LINE bot. The system provides analytical charts, allowing teachers to instantly comprehend the status of students' self-learning and assess the necessity for additional learning support. The teaching experiment was implemented after the experimental design, and the experimental result was analyzed in three dimensions, including the question reading, self-test, practicing incorrectly answered questions, and competitive question answering situation.

3.2.1. Question reading

This section primarily provides information on the amount of questions. Students are currently reading in the Q&A database, along with the interval time for each question. This allows teachers to gain insights into students' engagement with the Q&A database, facilitating real-time monitoring of students who may be falling behind in progress. Fig. 14 presents the question reading performance of all learners who interacted with the LINE bot. Learners were randomly assigned participant numbers ranging from #1 to #10. Among the 10 learners, participant #3 had the best performance. Participants #1, #5, #7, and #8 had read a few questions; for those students who are falling behind in progress, teachers can monitor their reading status and provide assistance.

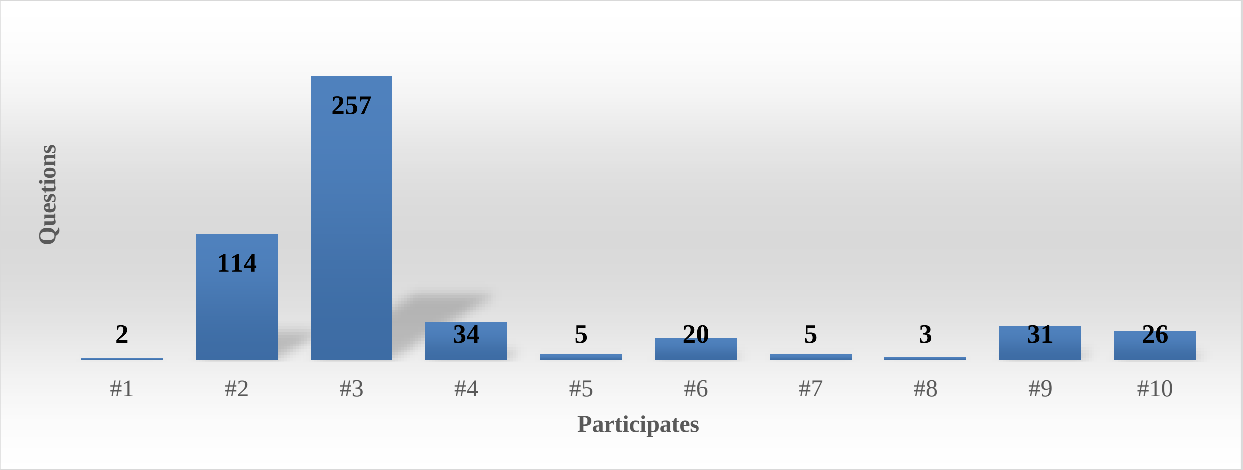


Fig. 14 Student question reading data

The system also provided data regarding the time interval between reading each question to help teachers better understand student learning. The following example illustrates the teacher randomly selecting participants #2 and #3 for further investigation. A comparison of the question reading data for two random participants is presented in Fig. 15. The curve of participant #3 is significantly wavier than that of participant #2. This indicates that participant #3 had longer reading intervals and spent more time reading the same questions, suggesting less engaged participation.

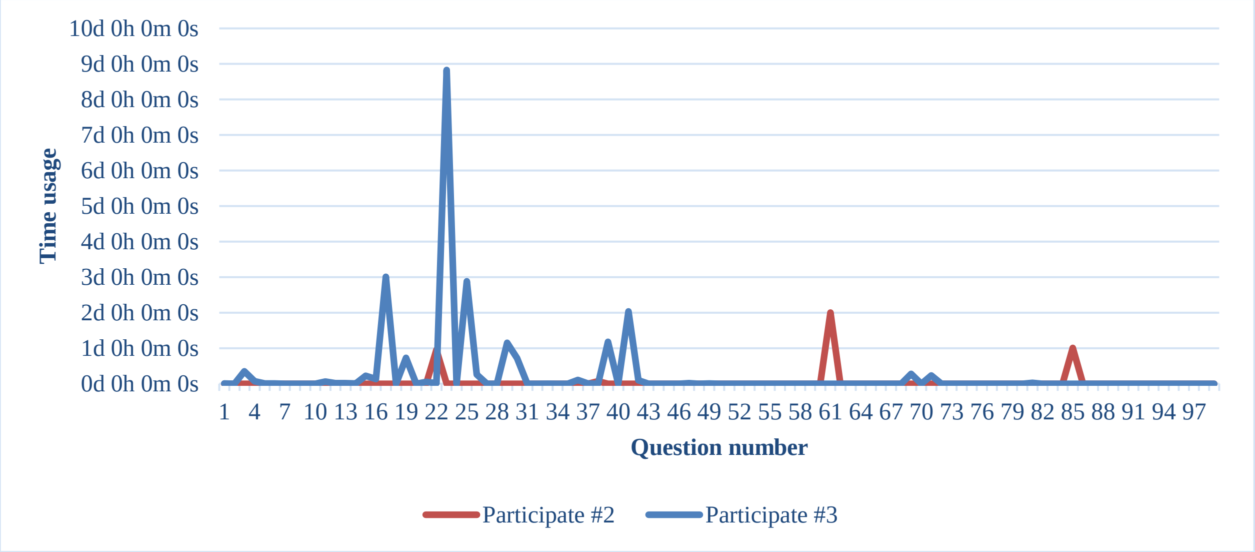


Fig. 15 Question reading intervals for two students

3.2.2. *Self-test*

In this section, learners will reinforce their learning outcomes through the S-R model. After reading the questions, learners can conduct self-test to understand their cognitive status of the subject. The system will also provide current analysis results for the teacher's reference, allowing for attention and assistance to students with poor self-test performance. The following example demonstrates that, after a period of self-learning, nine learners participated in self-tests, randomly numbered as participant #1 to #9. The system provided self-test data (Fig. 16). Participant #1 had the best self-test performance. That of participants #2, #4, #6, and #7 was worse; for participants who exhibit poor performance in self-test, teachers can provide care and assistance.

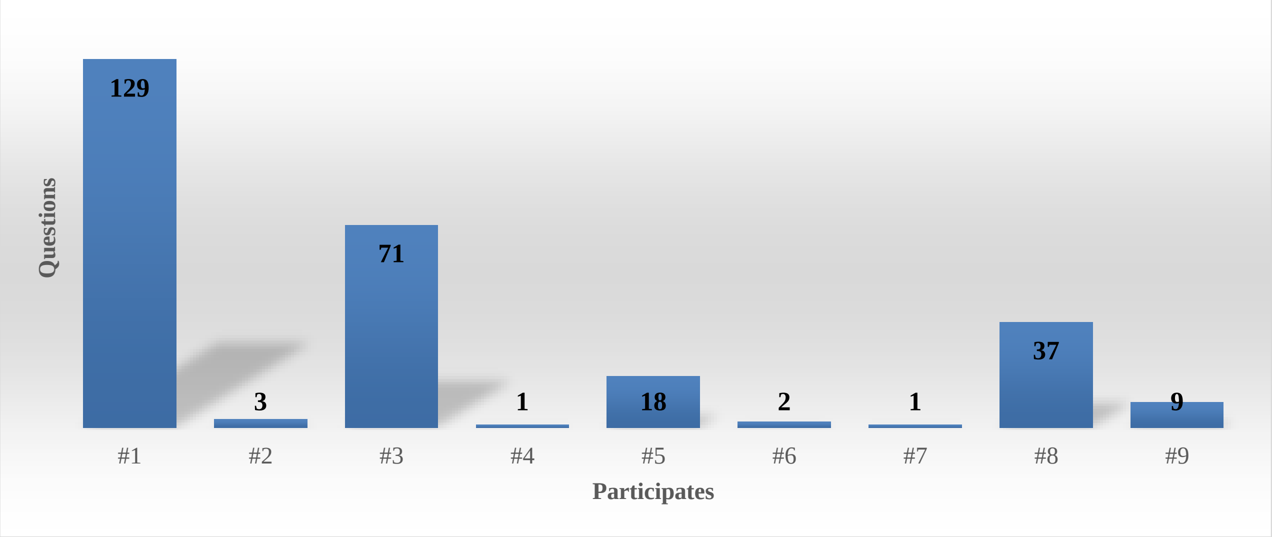


Fig. 16 Self-test performance

The system also provided data on the time intervals between each self-test question. The following example illustrates the teacher randomly selecting participants #1 and #3 for further investigation. A comparison of the data for two random participants is presented in Fig. 17. The curve of participant #3 is significantly wavier than that of participant #1. The intervals between self-test questions for participant #3 are longer., indicating less self-testing activity.

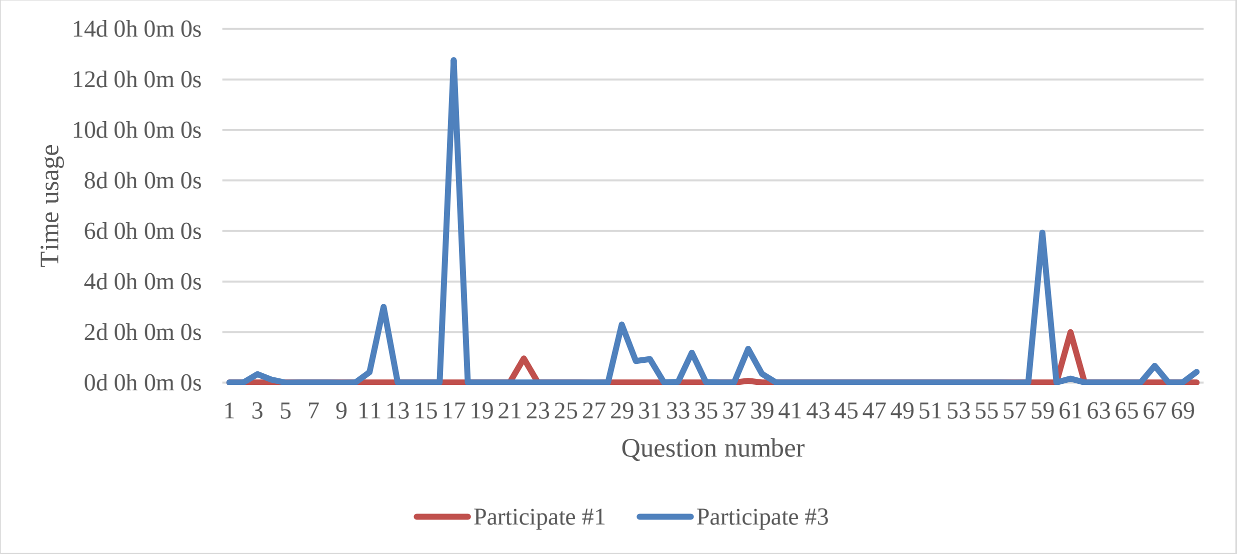


Fig. 17 Self-testing intervals for two students

3.2.3. *Practicing incorrectly answered questions*

In this section, learners have the opportunity to engage in repeated practice for incorrectly answered questions, reinforcing learning outcomes through the S-R model. The system will also provide the current status of error-practice sessions for the teacher's reference, allowing for attention and assistance to students with fewer instances of error-practice. The following example demonstrates that, after a period of self-learning, four learners participated in error-practice sessions, randomly numbered as participant #1 to #4. Fig. 18 presents the data regarding practice for incorrectly answered questions. Four learners practiced questions; participant #1 had a higher frequency of error-practice sessions. Other participants engaged in fewer instances of error-practice sessions. For these students, teachers can provide care and assistance.

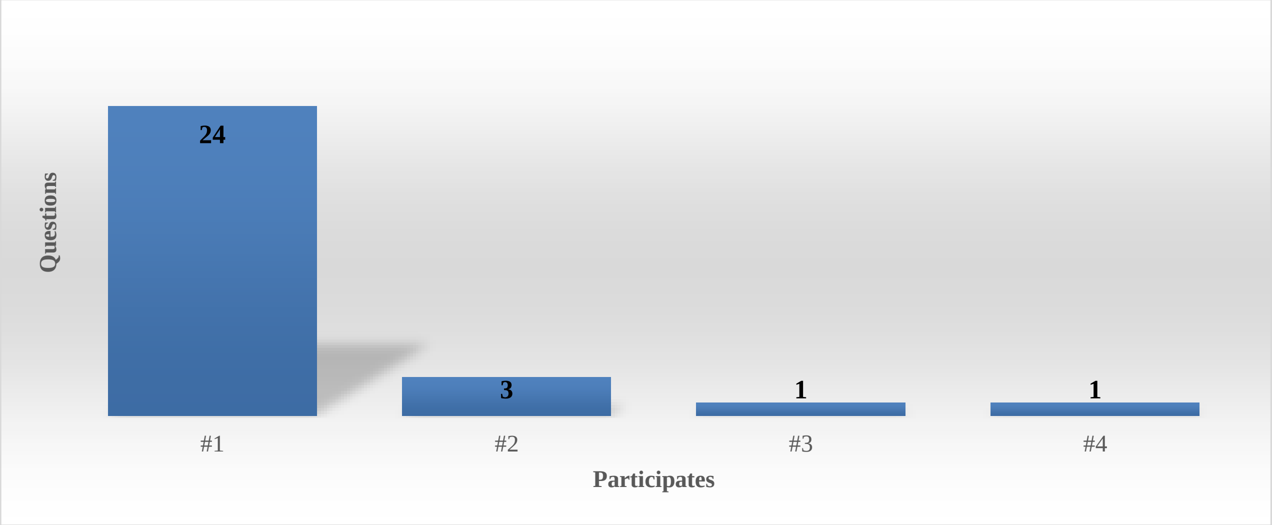


Fig. 18 Comparison of the practice of questions answered wrongly

3.2.4. *Competitive question answering situation*

The system incorporates gamified elements of competitive question answering to motivate learner engagement. During self-learning periods, spontaneous quiz events are held to reinforce the S-R model through gameplay. Throughout this period, a total of eight learners participated in a competitive question answering situation, randomly numbered as participant #1 to #8. The data collected regarding the eight learners that participated in competitive question answering is displayed in Fig. 19. Participant #2 participated the most, followed by participants #1 and #6. Teachers can provide positive reinforcement to learners who participate in competitive question answering, encouraging them to be more willing to engage in such activities.

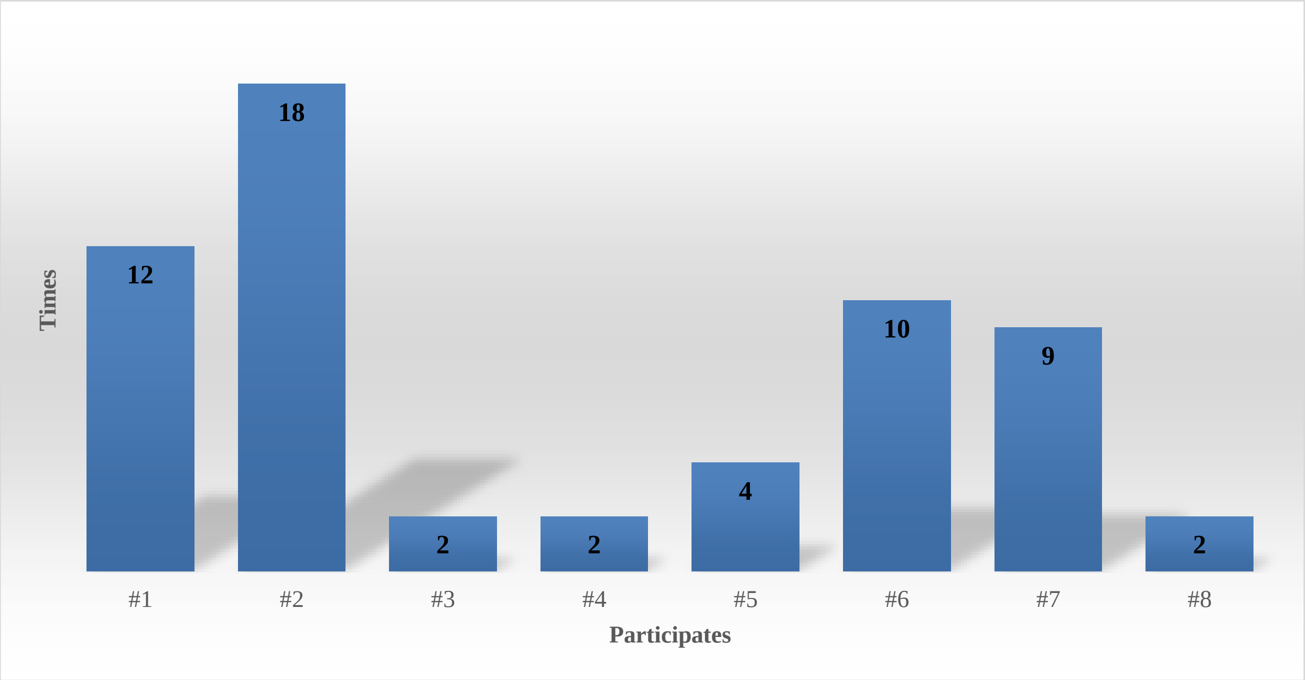


Fig. 19 Participation in competitive question answering

3.3. *Discussions*

Typically, asynchronous question-based digital learning systems only provide immediate feedback and repeated training to enable students to achieve cognitive learning. The lack of teacher monitoring and boring learning processes often affect learners' learning motivation, leading to poor learning effectiveness. This study presents a quasi-synchronous M-learning method that successfully imitated traditional cognitive question database teaching methods. The LINE bot could replace the teacher and the learners could learn anytime, anywhere. Moreover, the system provides analytical charts, allowing teachers to instantly comprehend the status of students' self-learning and assess the necessity for additional learning support.

4. Conclusions

The guidelines for research on information systems were used to propose a design science research process for the system. The system functions, namely Q&A database learning, gamification learning, and open-ended questions, were rigorously validated. Moreover, the system provided student data regarding their question reading, self-test, practice, and competitive question answering performance. The system was confirmed to meet all functionality requirements. Hence, the LINE bot, a quasi-synchronous M-learning bot that transcends traditional Q&A database learning, has attested to its practicability in this study. The M-learning system imitates a traditional educational context. A recommendation algorithm was used to reference a knowledge base to answer open-ended learner questions, enabling the LINE bot to replace the teacher by enabling one-on-one synchronous interactive learning. Including gamification elements prevented the system from being boring. The LINE bot also performed an analysis of student learning interactions, providing data to the teacher to enable them to better understand student learning and offer adequate assistance and counseling.

The LINE bot could be applied by teachers to train students to become Class B technicians for computer hardware fabrication. In the future, teaching experiments will be planned to investigate the learning effectiveness and satisfaction during assisted learning, aiming to understand its effectiveness in educational assistance.

Conflicts of Interest

The authors declare no conflict of interest.

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