International Journal of Instruction *January 2026 ● Vol.19, No.1*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 387-400

Article submission code: 20250523083404
Received: 23/05/2025
Revision: 10/08/2025
Accepted: 23/08/2025
OnlineFirst: 03/10/2025

Interactive learning with Staggered Online Quizzes and Discussion Enhanced Students' Motivation and Performance

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An interactive learning was incorporated with staggered online quizzes using the Quizizz app to promote motivation and real-time intervention. This study examines the students' motivation and performance during interactive learning. The two-hour interactive learning included short lectures, reflection, interactive discussions, practice application questions, and staggered online quizzes, with students logging in via QR codes. The top scorers were announced, and answers were discussed. After three weeks, a Google Form questionnaire assessed students' motivation and learning strategies. Grades from the staggered quizzes were tabulated and statistically analyzed. Results showed the game elements, namely challenges, instant feedback, social engagement, and leaderboard were significantly correlated to students' motivation. The immediate feedback improved students' confidence and increased their attentiveness in class, which correlated with improved quiz performance. In conclusion, interactive learning with staggered quizzes and discussions enhances motivation and performance. The game elements provided a positive environment that enhances participation and motivation. The instant feedback from the online Quizizz app provided both the lecturer and student with information about their learning process and, with appropriate intervention, clarified the misconceptions. However, further research is needed to explore students' struggles with applying their learned cognitive and critical thinking skills to new or unfamiliar topics.

Keywords: interactive learning, quiz, gamification, motivation, performance

Citation: Choo, C. Y., Ming, L. C., Devi, J. A., & Kiran, S. R. (2026). Interactive learning with staggered online quizzes and discussion enhanced students' motivation and performance. *International Journal of Instruction*, *19*(1), 387-400. https://doi.org/10.29333/iji.2026.19119a

INTRODUCTION

Active learning was introduced as the instructional strategy for newly enrolled first-year pharmacy students in the 2024/2025 academic year. This aligns with the need to meet the challenges of the emerging complex knowledge society to ensure a sustainable future. This initiative offers a significant opportunity for students to engage actively with course materials during lectures. Having undergone at least 12 years of traditional classroom-based learning, these students experience a transition to active learning that aims to foster higher-order thinking skills. For the first time, they will experience flipped and active learning. Higher-order thinking skills include critical thinking, problem-solving, creativity, collaboration, and communication (Meok et al., 2024).

Training students in higher-order thinking skills is essential because it enables them to analyze, evaluate, and create, which are skills critical for addressing real-world problems and adapting to a fast-changing, complex environment. These skills promote lifelong learning, allowing students to become self-directed and independent thinkers capable of pursuing knowledge on their own. Moreover, higher-order thinking fosters creativity and innovation, preparing students for future roles that cannot be replicated by machines (World Economic Forum, 2020). The theoretical background behind active learning was constructivist theory.

Theoretical background

Constructivist theory in education emphasizes that learners actively construct their understanding and knowledge through experiences and reflection. This approach encourages active learning, where students engage in problem-solving and critical-thinking activities that build on their prior knowledge. Constructivist educators promote collaboration, discussion, and hands-on activities, believing that learning is most effective when students are actively involved in the process. Recent studies have shown that constructivist methods enhance student engagement, critical thinking, and knowledge retention (Chand, 2023). Gamification complements the constructivist paradigm by embedding learners in dynamic, simulated environments, leaderboard, and a feedback loop that fosters exploration and application enabling learners to build cognitive structures through authentic, hands-on learning. Studies have shown that such approaches enhance conceptual understanding and skill development in higher education contexts. (Murillo-Zamorano et al., 2021; Khaldi et al., 2023).

The transition from conventional learning to active learning is likely to encounter resistance from students, as it requires them to study and understand the material before attending active learning. They need to reorientate to a new learning approach and manage their time to prepare for the lesson. Analyses revealed both explanation and facilitation strategies lowered the student’s resistance (Madison et al., 2022). Thus, students were explained the reason for the transition, and interactive activities using technological advancement, namely online apps were developed to facilitate this transition. Technology can enhance learning experience (Alessa, 2025).

The flipped classroom model was introduced to allow students to engage in active learning during class time. Essentially, "flipping the classroom" means that students first encounter new material outside of class, typically through reading or lecture videos. Then, they use class time to tackle the more challenging aspects of understanding that knowledge, such as problem-solving or discussion (Hsia et al., 2022). According to Bloom's revised taxonomy, this approach allows students to handle lower levels of cognitive work—such as gaining knowledge and comprehension—outside of class, while focusing on higher-order cognitive tasks like application, analysis, synthesis, and evaluation during class time. This shift provides students with the support of their peers and instructor. This model contrasts with the traditional approach, where students are first exposed to new material through lectures in class and then absorb that knowledge through homework. Hence, the term "flipped classroom."

During class, students were expected to engage in exercises that helped them apply the concepts in solving problems. These activities are expected to train students in critical thinking skills. Staggered online quizzes were created to assess students in real-time on their performance after active learning. It's a tool used by lecturers to gauge students understanding and provide real-time interventions. These activities in active learning must deliver the specified content knowledge, regardless of whether they are delivered in an active or traditional didactic learning format. Content knowledge is needed to achieve appropriate critical thinking in the knowledge domains to solve higher-order thinking questions (Choo et al., 2022).

The 2-hour lecture content was redesigned into smaller segments similar to microlearning. Quizzes, discussions and problem-solving activities accompanied each segment to align with the course learning outcomes. Quizzes were administered using the Quizizz app to gamify the learning experience, reducing resistance during students' first encounter with active learning. This study aims to assess the 1) the effect of the game elements on students' motivation and learning strategies, and 2) the correlation between students' motivation and their learning strategies on their performance in active learning.

METHOD

Participants

A quantitative, cross-sectional, self-administered online questionnaire was conducted with the 242 newly enrolled first-year pharmacy students of the 2024/5 batch at UiTM Puncak Alam. Due to the limitations of seating in the lecture halls, the students were divided into two groups of 121 each. The same lecture content was presented twice by the same lecturer. A total of 163 responses were received.

Study Design

The interactive learning format was introduced in the Fundamentals of Chemistry module, covering the weeks from Week 9 to Week 11. During this period, the lectures addressed topics including Polyunsaturated Hydrocarbons, Alkyl Halides, and the mechanisms of Substitution (Sn1 & Sn2) and Elimination (E1 & E2) reactions. During Week 9, students received a briefing on the course learning outcomes, assessment distributions and reasons for active learning. They were also reminded to complete the flipped learning materials before the two-hour active learning session.

One week before each lecture, students were provided with instructor-generated videos available on YouTube, along with lecture notes. The videos included embedded questions, and answers to these questions have been accessible to everyone since they were uploaded to YouTube. The interactive learning sessions were held twice a week, with an attendance of 121 students per session.

The content of the 2-hour lecture was divided into smaller segments, each lasting 20 to 30 minutes. After each segment, students completed online quizzes featuring multiple-choice questions, which included options for either a single best answer or multiple correct answers. During Week 10 lecture hours, the students participated in an online quiz (Quiz A) that incorporated both types of questions (Table 1). The first quiz was designed to assess their understanding of the flipped learning material. Following the quiz, there was a session for students to reflect on their answers and practice solving application questions. After this discussion, students were evaluated again with additional online quizzes (Quiz B and C), during which they reflected on and discussed their answers to Quiz C.

Table 1
Lesson Plan during the 2-hour interactive learning

Weeks	Activities	Topics
10	Quiz A	Subtopic 1
	Reflection & interactive discussion	Subtopic 1
	Short lecture	Subtopic 2
	Practice application questions	Subtopic 2
	Quiz B	Subtopic 2
	Quiz C *Reflection & interactive discussion*	Subtopic 3 Subtopic 3
11	Quiz D	Subtopic 4
	Reflection & interactive discussion	Subtopic 4
	Short lecture	Subtopic 5
	Practice application questions	Subtopic 5
	Quiz E	Subtopic 5

In the following week, Week 11, the students completed another online quiz (Quiz D), followed by reflection and discussion of its questions (Table 1). This was succeeded by a short lecture and discussion on how to solve an application question. Finally, students took another online quiz (Quiz E). The accuracy of the students' responses was recorded, and the average results for the two groups were compiled.

The first-year students were evaluated with multiple choice questions (MCQ) on the lower and middle levels of Bloom's Taxonomy, specifically focusing on the 'Remember,' 'Understand,' 'Apply' and ‘Analyze’ categories. The lower and middle levels were assessed because it is easier to identify which parts the students do not understand and provide intervention. The Quizizz app (rebranded to Wayground app) facilitated online quizzes, with students logging in via a QR code projected on the whiteboard, utilizing the free Wi-Fi connection in the lecture hall. To participate in the quiz, students were required to write their names. Once the quiz concluded, the leaderboard was displayed, and students could review their marks, allowing for a review of performance. Students and facilitators discussed the questions that had lower accuracy, encouraging students to reflect on their answers and engage in inquiry about alternative responses.

Following this discussion, additional questions were presented that required students to apply scientific theories and concepts to solve problems. The student who provided the correct answer was asked to present their solution, while peers had the opportunity to add to or correct the presented answer.

After each session, students were allowed five minutes for rest or peer discussion before proceeding with the next activity.

Questionnaire Development and Its Validation

The questionnaire used in this research project was adapted from an unpublished report. Pilot testing of the questionnaire had been conducted by the earlier study, which showed good face and content validity. To assess face validity, which included evaluating the readability, length, and relevance of the online questionnaire, three senior pharmacy lecturers who were trained in questionnaire design provided their feedback on the content validity. Additionally, pre-testing involved 38 students testing the face validity by rating the clarity of each item, relevance to active learning, and gamification. The majority of the students (85%) find the questions easy to understand and relevant. The internal consistency of the final questionnaire was measured using Cronbach's alpha coefficient, which had a value of 0.74. The difficulty of the questions for quizzes A-E was average, with a difficulty index of between 0.41-0.63. These questions were able to identify the high and low scorers as they have very good discriminant index of between 0.55-0.67. The internal consistency of these questions was high with Cronbach's alpha coefficient of 0.82.

Data Analysis

The 5-point Likert scale was employed to assess students' perceptions of each question's difficulty level. It was rated as strongly agree (5.0), agree, neutral, disagree, and strongly disagree (0). The descriptive mean score, standard deviation, and Cronbach's alpha value were calculated using SPSS (Version 28). Cronbach's alpha index was used to calculate the internal consistency, with values between 0 and 1, with those ≥0.70 being adequate and up to 0.95 being good (Terwee et al., 2006). Moreover, there were no missing values in Google Forms.

FINDINGS

Effect of the game elements on students' motivation and learning strategies

The game elements, namely challenge, immediate feedback, social engagement and leaderboard, were strongly linked to students' motivation and learning strategies (Table 2). These elements were correlated to enhanced students' learning experiences, especially when using online platforms like Quizizz.

Table 2
Correlation between game elements in Quizizz and student motivation

No.	Descriptions	Game Elements in Quizizz			
		Challenging	Immediate Feedback	Social engagement	Leaderboard
	Motivation				
1.	I enjoy the online quiz during the lecture.	0.644**	0.728**	0.604**	0.459**
2.	I learned my mistake when the lecturer explained the answers	0.546**	0.671**	0.625**	0.407
3.	I highly recommend quizzes for each sub-topic in lectures	0.606**	0.669**	0.683**	0.483**
4.	When I see my friends answering, it makes me anxious as I did not study	0.365	0.378	0.471**	0.434**
	Learning strategies				
5.	I find the questions relevant to test myself	0.624**	0.672**	0.671**	0.454
6.	I learned MORE with this online quiz during the lecture than without an online quiz	0.429	0.536**	0.480**	0.497**
7.	The quiz helps me to be attentive during the lecture	0.599**	0.671**	0.640**	0.493**
8.	I search online for answers to my wrong answers	0.493	0.473**	0.545**	0.449**

**$p<0.001$

Students enjoyed the online quiz during lectures and highly recommend having quizzes for each sub-topic were significantly correlated to all the game elements, namely challenging, immediate feedback, social engagement, and leaderboard (Table 2). The challenge from the game element was correlated to students' attentiveness during the lecture, and learning from their mistakes when the lecturer explained the answer.

With immediate feedback, students learned from their mistakes (r^2=0.671), became more attentive during lectures (r^2=0.671), and actively sought answers to the questions they got wrong (r^2=0.473).

Social engagement is another game element that was significantly correlated with anxiety when compared with friends who could answer the questions, learning from mistakes, and search online for their wrong answers. The leaderboard was highly correlated with students' enjoyment, anxiety when seeing friends able to answer, learning more, being attentive in class, and searching for answers online.

Students' motivation, learning strategies, and quiz performance

Analysis of quiz questions

The instructional design directly impacts the accuracy of quiz scores. The questions in Quizzes A-E were average type of difficulty, as indicated by the difficulty index of between 0.41-0.63, and have a very good discriminant index of between 0.55-0.67 in the validation of the questions. The multiple-choice questions included either a single best answer or multiple correct answers (Table 3).

Table 3
Type of multiple-choice questions in Quizizz app

No.	Type	BT level	Question
1	Single best answer	L1	Which are nucleophiles?
2	Multiple correct answers	L2	The following statements are TRUE of Sn1 reactions (>1 answer).
3	Multiple correct answers	L3	Which of the following sets of conditions would most likely lead to an E2 elimination rather than substitution?
4	Multiple correct answers	L4	A reaction gives a racemic mixture as product. Analyze which substitution mechanism is more likely and explain why?

L1=Remember; L2=Understand; L3=Apply; L4=Analyze.

The single best answer is simple questions from the Bloom's Taxonomy (BT) lower cognitive level, namely, remember (L1) or understand (L2). An example of this question is "Which are nucleophiles?" (Table 3). The student will need to recall the correct nucleophile from a list of compounds. For an L2 (Understand) question is "the following statements are TRUE of Sn1 reactions (>1 answer)". This question requires students to comprehend and recognize accurate conceptual statements about the Sn1 mechanism (e.g., carbocation formation, rate-limiting step, substrate structure, solvent effects). The higher cognitive level question was the Apply (L3) and Analyze (L4) type of question. The L3 type of question requires the student to apply knowledge of reaction mechanisms to a specific chemical scenario. It tests understanding in context (not just recognition or recall). Students must connect concepts of substrate structure, solvent effects, and mechanism type to predict the product. While the L4 (Analyze) type of question requires the student to interpret evidence (formation of a racemic mixture), break down mechanistic pathways (SN1 vs SN2), determine the most likely mechanism based on reaction outcome and finally justify the answer using chemical reasoning.

By incorporating the L1-L4 cognitive levels of Bloom's Taxonomy (BT) in the questions, the lecturer can analyze student responses to better adapt the discussion topic and tailor the short presentation. This approach helps clarify any misconceptions or concepts that students may find confusing after the flipped learning experience. With the misconceptions clear, its easier for students to practice on higher-order-thinking (HOT) questions.

The short lecture covers concepts that most likely students find confusing after the flipped learning. To strengthen students' confidence, they were given questions to practise in class after the short lecture (Figure 1).

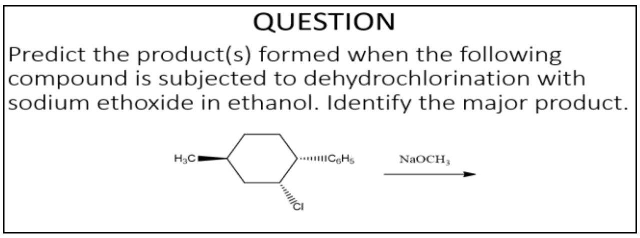

Figure 1
An example of HOT question

Students need to apply the higher BT cognitive levels of evaluate (L5) and create (L6) and relate to their pharmacy profession. Students need to judge the reactants' active functional group and the reaction condition, to justify the probable mechanism of reaction, namely unimolecular nucleophilic substitution (Sn1), bimolecular nucleophilic substitution (Sn2), unimolecular elimination (E1), or bimolecular elimination (E2), and finally generate the final major and minor products. Some of the hypothetical real questions related to their pharmacy profession include the purity of the final product concerning the International Council for Harmonisation (ICH) Guidelines on Q3A(R2) impurities in new drug substances, what the impurities are, the effect of impurities, and the chemicals used in relation to the sustainable development goals (SDG) commitment. Many variations to the reactant chemical structures of a similar type of higher-order-thinking (HOT) question can be used in the lecture hall to challenge the students' critical thinking, problem-solving, creativity, collaboration, and communication skills.

Students quiz performance

The first quiz (Quiz A) questions were administered to the students at the beginning of the lecture and showed a low accuracy of 49% (Table 3). The students scored significantly higher in Quiz B after completion of the short lecture and hands-on practice with application questions, and returned to significantly lower scores when assessed in Quiz C. The next week, the student's first quiz (Quiz D) scored lower accuracy, but after the interactive learning, they scored Quiz E significantly higher. Quiz A and D were the first quizzes for the week's lecture to

Table 3
Analysis of quiz participation and performance

Week	Quiz	Participants (%)	Accuracy (%)	Sig.
10	A	96.7	49^{a}	$<0.001^{a}$
		Interactive learning		
	B	96.7	$82^{a,b}$	$<0.001^{b}$
	C	96.7	49^{b}	
11	D	95.9	48^{c}	$<0.001^{c}$
		Interactive learning		
	E	94.2	74^{c}	

Significant paired t-test for a: Quiz A & B, b: Quiz B & C, c: Quiz D&E.

assess the student's cognitive skills in flipped learning, and both have low accuracy (Table 3). The immediate feedback loop on the students' quiz performance allowed appropriate intervention, namely interactive discussion to understand the student's learning perspective was applied based on these results. This was followed by a short lecture and practice on application questions. After the intervention, students' performance increased as shown in Quiz B and Quiz E. The percentage participation of each of the quizzes was high, between 94.2-96.7 % showing students were motivated to participate in the active learning.

Correlation between students' motivation and their learning strategies on their performance

The student's motivation level and learning strategies were rated high between 4.1 to 4.6 (Table 4). Students enjoyed the online quizzes on the Quizizz app during the 2-hour interactive learning and rated it highly (4.6 + 0.8) and found the questions relevant (4.5 + 0.8) (Table 4). The top three high scores on the quiz were displayed on the leaderboard. The low-accuracy questions that most students answered wrongly were discussed interactively and reflected on in the lecture hall. The immediate feedback increased the students' confidence and was rated highly (4.6 + 0.8) and enhanced their motivation (4.5 + 0.8). They strongly recommend having quizzes for each sub-topic discussed in the lecture.

Table 4
Students motivation, learning strategies, and quiz performance

No.	Description	Average + std dev	Quiz p-value
	Motivation		
1	Receiving immediate feedback on quizzes after each sub-topic boosts my confidence in that subject.	4.6 + 0.8	0.138*
2	Seeing my friends respond motivates me to study and prepare better for the next lecture.	4.5 + 0.8	-
3	I like to challenge myself regarding my understanding of topics I studied before the lecture.	4.4 + 0.9	-
4	I want to see my name on the screen when I am top three in the class.	4.2 + 0.9	-
5	I learned my mistake when the lecturer explained the answers	4.6+ 0.8	-
6	I enjoy the online quiz during the lecture.	4.6 + 0.8	-
7	I highly recommend quizzes for each sub-topic in the lecture.	4.6 + 0.8	-
8	When I see my friends answering, it makes me anxious as I did not study.	4.1 + 1.1	-
	Learning Strategies		
9	I discuss questions I got wrong with my friends after lecture	4.3 + 1.0	-
10	I compare answers with my friends after completing each quiz	4.0 + 1.2	-
11	The quiz helped me stay attentive during the lecture	4.6 + 0.8	0.145 **
12	I find the questions relevant for self-evaluation.	4.5 + 0.8	-
13	I learned MORE with this online quiz during the lecture than without online quiz	4.5 + 0.9	-
14	I search online for answers for my wrong answers	4.2 + 0.9	-

Cronbach alpha value=0.96; *Significant $p<0.05$ vs Quiz B; ** $p<0.001$vs Quiz E

Students strongly agree (4.5 + 0.9) that they learned more with the staggered online quizzes incorporated during the 2-hour interactive learning than without quizzes. The immediate feedback provided by the quiz helped clarify the solutions to the problems. The students learned about their mistakes during the feedback, motivating them to be attentive during class. The quiz-initiated conversations with friends when they started comparing and discussing answers. It also motivated them to search online for answers. Receiving immediate feedback and staying attentive during lectures was significantly correlated with the performance of Quiz B and Quiz E, respectively (Table 4).

DISCUSSION

Active learning with a flipped classroom was introduced to the present cohort of students enrolled in 2024/5 majoring in the Bachelor of Pharmacy (Hons). Most students experience a minimum of 12 years of conventional learning and will experience active learning for the first time. The two-hour lecture was conducted in interactive mode. The flipped material, namely lecture notes and pre-recorded video lectures on YouTube, was provided to the students one week before the scheduled face-to-face interactive learning. Students self-assessed their understanding of Bloom's taxonomy, lower cognitive level questions on knowledge, understanding, and simple application using Escape Rooms. The lower cognitive level questions were chosen to encourage students to complete the flipped learning materials and build their confidence with active learning. In flipped learning with escape rooms for self-assessment, there was an increase in lecture preparedness and engagement rates of pre-recorded video lectures, with students reporting higher motivation, enjoyment, and confidence in their knowledge (Long & Choo, 2025).

Gamification was introduced to create a positive environment to avoid students' resistance towards active learning, since this is their first time experiencing it. The game elements, such as challenges, immediate feedback, social engagement, and leaderboards, were found to be significantly correlated with students' motivation and learning strategies. These elements have created an environment in which students enjoyed participating in assessments using the online Quizizz app (see Table 2). This positive learning atmosphere enhances their motivation to learn (Han, 2025). The online Quizizz app allowed immediate feedback to both the students and the lecturer. The students could immediately correct their mistakes while the lecturer could change the teaching instruction to adapt to the students' understanding. The open lecture hall allowed students to have a healthy competition, and thus the leaderboard was rated high (4.2 + 0.9) (Table 2). Competition among peers was shown to improve students' performance. Competition creates motivational boosts to improve performance (Kawarazaki et al., 2023). Healthy competition in education can significantly benefit students by fostering motivation, resilience, and essential life skills. It encourages students to strive for personal improvement while respecting others' efforts and achievements. This type of competition helps develop critical thinking, time management, and problem-solving abilities, which are components of higher-order thinking, and it is crucial for success in both academic and real-world settings. Additionally, healthy competition can boost self-esteem and engagement, as students discover new talents and seek opportunities to improve. Overall, it prepares students for future challenges by teaching them to handle success and defeat gracefully. In this study, students were motivated to study when they saw their peers studying. This motivation may have risen from competition between peers, which was observable in the lecture hall.

The online Quizizz app allowed real-time analysis of students' accuracy and immediate feedback, giving information about learning processes and clarifying misconceptions to minimize the gap between the current level and the intended level of learning. This motivated students' learning, thus students' high participation was observed (Table 3). After each quiz, students could correct their understanding during the reflection and interactive discussion. This was followed by a short lecture on difficult-to-understand concepts and practicing application questions related to their profession. The accuracy in Quiz B and E (Table 3) improved significantly, but students were unable to apply their problem-solving skills to new sub-topics, namely Quiz A, C, and D. The quizzes

A, C, and D showed poor performance with low accuracy. Quizzes A and D assessed students on their earlier flipped learning. Guidance in the form of discussion is needed to help students relate the concepts in problem solving.

Although the students enjoyed with high participation percentage of the online quizzes, and, in their comments, they wanted to practice more of these questions, the quiz performance showed poor results. Based on the students' performance in quizzes A, C, and D, gamification elements created a positive environment; however, they did not directly correlate with student performance. Conversely, without gamification, students may be less likely to participate in the quizzes. Therefore, gamification serves as an effective way to encourage student participation, as the instant feedback obtained from these quizzes is essential for interventions. This observation on the use of information and communication technology (ICT) was similar to a study by Chen et al. (2025) where they reported that ICT use intensity at school was negatively related to students' complex problem-solving performance. Similarly, a study by Adi & Arhin (2025) showed that motivation did not improve academic performance; rather, high levels of academic satisfaction positively impact students' academic performance. The results from online quizzes have yet to show that students were able to be independent learners, but it has made the transition to active learning more attractive, as most students have adapted to active learning by the third lecture. The degree of independence depends on their confidence, prior experience, and the complexity of the new knowledge or task. Since this is the student's first exposure to active learning, with time and experience, they may acquire independent learning.

Active learning aims to develop critical thinking to solve application-based problems and bridge the theory-practice gap, thus promoting a deeper understanding of the material. Staggered quizzes and discussions during active learning sessions significantly enhance student engagement with the material. Our findings concur with this report. By periodically interrupting the lesson with short quizzes, the students' understanding can be assessed in real-time, providing immediate feedback, and adjusting teaching strategies accordingly (Heise et al., 2020). This approach not only keeps students attentive but also promotes active participation. Studies have shown that active learning techniques, including quizzes, lead to higher student performance and motivation compared to the traditional lecture-based methods (Lamon et al., 2020). Similarly, Lamon et al. (2020) demonstrated that active learning experiences in online postgraduate courses significantly improved student satisfaction. In addition, assessments like quizzes can be used as an effective tool to guide students toward adopting a deep approach to learning (Baeten et al., 2010). Critical thinking and problem-solving skills are widely considered an acquired skill set, developed through education, experience, and exposure to diverse perspectives. Amani & Mkimbili (2025) highlight the role of instructional interventions in enhancing critical thinking skills, emphasizing that these abilities are cultivated through structured learning environments. Similarly, Amin et al. (2020) demonstrate how problem-based learning fosters critical thinking, illustrating its dependency on active engagement and practice. Sellars et al. (2018) argue that critical thinking evolves as a mindset and skill set shaped by conversations and reflective practices. Developing effective critical thinking and problem-solving skills takes time and remains challenging; it is not something that can typically be successfully taught in a set of decontextualized lectures, but rather a process to engage with (Chao & Wright, 2025). Time is needed to develop logic and reasoning skills (Heard et al., 2020). These findings underscore that critical thinking is not innate but nurtured over time. Designing the proper assessment tools will help to develop both problem-solving and critical thinking skills. Further study is needed to understand this observation as it is related to many factors, namely, students' deep learning, domain-specific problem-solving skills, type of questions, assessment tools, etc.

For active learning to be successful, effective student preparation is crucial. Assessment after the flipped learning in Quizzes A & D showed students were unable to bridge the gap between flip and active learning, although students rated highly on the gamification elements. A more effective method or type of question should be explored in the future. Further study is required to enhance effective learning to cultivate problem-solving and critical thinking skills to apply to new topics.

LIMITATION

The study is limited to the first cohort of students enrolled in active learning for 2024/25. The effect of a staggered online quiz was conducted on first-year students. No longitudinal study was conducted. The use of multiple-choice and single-best-answer quizzes with low and middle cognitive levels has limitations when it comes to assessing students' critical thinking skills, but it is a good tool to gauge students' understanding and provide interventions. Alternative assessment methods, such as problem-based or real-world questions, that engage higher levels of Bloom's taxonomy, are needed to train and evaluate students' critical thinking and problem-solving skills.

CONCLUSION

Interactive learning with staggered quizzes and discussions enhances motivation and performance. The game elements, namely challenges, instant feedback, social engagement, and a leaderboard, provided a positive environment that enhances participation and motivation. The instant feedback from the online Quizizz app provided both the lecturer and student with information about their learning process and, with appropriate intervention, clarified the misconceptions. However, further research is needed to explore students' struggles with applying their learned cognitive and critical thinking skills to new or unfamiliar topics.

FUNDING

No funding was received for this study.

Conflict of interest

The authors declare no conflict of interest.

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