

The Impact of Gamified Escape Room Activities on Student Learning and Engagement in a Computer Database Course

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Abstract—This study examines the impact of gamified escape room activities on student learning performance and engagement in a university-level database design course. A quasi-experimental repeated-measures design was used to compare the traditional learning approach with a gamified escape room incorporating quizzes, points, leaderboards, and nicknames. The gamified escape room featured defined goals, a game character, interactive tasks, immediate feedback, problem-solving challenges, and a fun learning environment. Results from the Wilcoxon Signed-Rank test showed significantly higher post-quiz scores and more consistent performance in gamified escape room-based quiz sessions. User engagement was assessed using the User Engagement Scale (UES), and students reported high levels of focused attention, perceived usability, aesthetic appeal, and reward. These dimensions align with the validated four-factor structure of the UES, which has shown good reliability and applicability across digital contexts. Aesthetic appeal received the highest rating, which implies that visually engaging and interactive design features played an important role in sustaining participation. Student feedback also indicated a strong preference for the gamified approach. These findings support the effectiveness of integrating gamification into classroom learning activities to enhance active learning, engagement, motivation, and knowledge retention.

Keywords—Gamified learning; escape room; quiz; database course; engagement; motivation

I. INTRODUCTION

The rapid advancement of digital technologies has transformed higher education, creating opportunities for innovative teaching approaches that support active and engaging learning experiences. Traditional lecture-based methods are often insufficient to sustain students' attention and participation. Consequently, educators are increasingly adopting student-centered pedagogical approaches that encourage interaction, collaboration, and experiential learning [1]. Among these approaches, gamification has gained prominence as a pedagogical approach to enhance student motivation, engagement, and improve learning outcomes in higher education [2, 3, 4].

Gamification refers to the application of game mechanics, such as points, badges, leaderboards, challenges, rewards and narratives to stimulate participation and improve user experiences [5]. Recent studies [6, 7, 8] have highlighted that gamification is an effective educational approach that encourages learners to solve problems and overcome challenges in game-based environments. Gamification offers innovative strategies to foster active learning and stimulate interest in academic content [9,10]. Inspired by this, escape room-based learning has been increasingly adopted in university settings to promote problem-solving, collaboration, knowledge retention and engagement through immersive and challenge-driven activities [11, 12].

Educational escape rooms transform traditional learning environments into interactive experiences where learners work under time constraints to solve content-related puzzles. These activities incorporate elements such as storylines, clues, and scoring, which have been shown to increase learners' engagement, motivation, and sense of accomplishment [13, 14]. When carefully aligned with learning objectives, such gamified methods can create deeper cognitive engagement, resulting in improved conceptual understanding and performance.

These advantages are particularly relevant to database education. Database courses require students to integrate theoretical knowledge with analytical reasoning and practical implementation while mastering complex concepts such as entity-relationship modelling, normalization, relational database design, SQL programming, and transaction management. Consequently, students frequently perceive database courses as abstract, cognitively demanding, and difficult to understand. While conventional paper-based quizzes remain a common method of content reinforcement, they often lack the dynamic interaction and immediacy that digital and game-enhanced activities can offer. To address these challenges, several studies have introduced gamification into database education. Schildgen [11] proposed MonsTER Park, an online educational game for learning Entity-Relationship Diagrams.

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The study revealed that students enjoyed the game and did not encounter any difficulties in completing the tasks. However, the study did not explore the effectiveness of MonsTER in increasing students' learning engagement. Similarly, Dæhli et al. [12] developed a web-based tool known as LearnER to teach basic data modeling skills. The study demonstrated that the use of gamification elements such as earning points and a high score list in the LearnER tool significantly motivated the students and contributed to their learning of the data modeling course. The study reported that some students need more precise information on how to earn more points. Another important insight from the study is that more advanced game mechanics would further motivate the data modeling learning engagement process. In addition, the use of interactive digital learning environments has demonstrated positive educational impacts. For example, Deng et al. [13] found that Pencil Code, a web-based programming platform, significantly improved students' computational thinking skills and computer learning attitudes, highlighting the potential of technology-enhanced and interactive learning environments to foster deeper learner engagement and positive learning experiences. Furthermore, Barra et al. [14] investigated the use of a remote educational escape room for database learning across four higher education courses over two academic years. Using pre- and post-tests, student perception questionnaires, and learning analytics collected through a web platform, the study demonstrated that remote educational escape rooms were both engaging and effective for teaching database concepts. Students reported high levels of enjoyment, immersion, and satisfaction, with more than 95% recommending that similar activities be incorporated into other courses. The findings suggest that educational escape rooms provide an effective approach for reinforcing theoretical database concepts while simultaneously developing collaborative problem-solving skills.

Although gamification has been explored in various academic contexts, limited research has focused on the effects of escape room-based quizzes on learning performance and engagement in university-level computer database courses. Database knowledge is essential in IT education. The database course was one of five information technology pillars in the 2008 ACM/IEEE Curriculum Guidelines for Undergraduate Degree Programs in Information Technology [15]. Furthermore, the most recent version of the ACM/IEEE Computer Society Task Group on Information Technology Curricula (2017) includes data modeling and database query languages as essential IT topics in information management [16].

Therefore, this study addresses the gap by evaluating how traditional and gamified escape room-based quiz learning activities influence students' post-lecture performance and their perceptions of learning within a database design course. Specifically, the study aims to examine the effectiveness of employing a gamified escape room on students' learning performance and engagement. To evaluate students' engagement levels, the User Engagement Scale (UES) was adopted as a measurement instrument to assess dimensions such as focused attention (FA), perceived usability (PU), aesthetic appeal (AE), and reward (RW). By incorporating both

learning performance and engagement measures, this study provides a more comprehensive understanding of the effectiveness of gamified learning activities in database education.

To guide this investigation, the primary research questions are formulated:

- Is there any significant difference in students' learning performance between paper-based quizzes and gamified escape room-based quizzes?
- To what extent do gamified escape room activities promote student engagement in terms of FA, PU, AE, and RW?

The main contributions of this study are twofold. First, the study provides empirical evidence on the effectiveness of gamified escape room-based quizzes in improving students' learning performance compared with traditional paper-based quizzes. The Wilcoxon Signed-Rank test results demonstrate significant improvement in students' post-lecture performance, which implies the effectiveness of gamified escape room activities as an active learning approach. Second, the study evaluates student engagement with the gamified escape room using the UES across four dimensions: FA, PU, AE, and RW. The findings reveal high levels of engagement across all four dimensions, with aesthetic appeal receiving the highest rating. This demonstrates that the gamified escape room provides an engaging and positive learning experience for students.

II. MATERIAL AND METHODS

A. Participants and Setting

The participants in this study were 200 undergraduate students enrolled in a Database Design course at a Malaysian higher education institution. All participants were aged between 18 and 26 years old. Before the study began, all students were briefed on the study's objectives and procedures and provided informed consent. The learning sessions took place in a face-to-face classroom setting and incorporated two types of structured learning activities: traditional paper-based quizzes and gamified escape room-based quizzes (gamified ER-based quizzes). These quizzes were not graded in the course assessment and were used purely as active learning tools to reinforce students' understanding of the lecture content and support knowledge retention.

B. Learning Tools

Traditional Quizzes: These were paper-based quizzes consisting of multiple-choice questions (MCQs) designed to assess students' understanding of key concepts presented during the lectures.

Gamified Escape Room Quizzes: These quizzes were delivered through an interactive digital escape room platform. Students solved a series of MCQ quizzes and challenges based on the lesson content. Elements of gamification such as leaderboards, badges, points, scores, and nicknames were embedded to enhance the student learning experience and motivation.

C. Study Design

This study employed a quasi-experimental repeated-measures design conducted over a period of four consecutive weeks. The same group of students participated consistently throughout the intervention. Fig. 1 illustrates the four-week study design combining lectures, quizzes, and gamified activities. Each week consisted of a scheduled face-to-face lecture accompanied by a pre-lecture and post-lecture quiz.

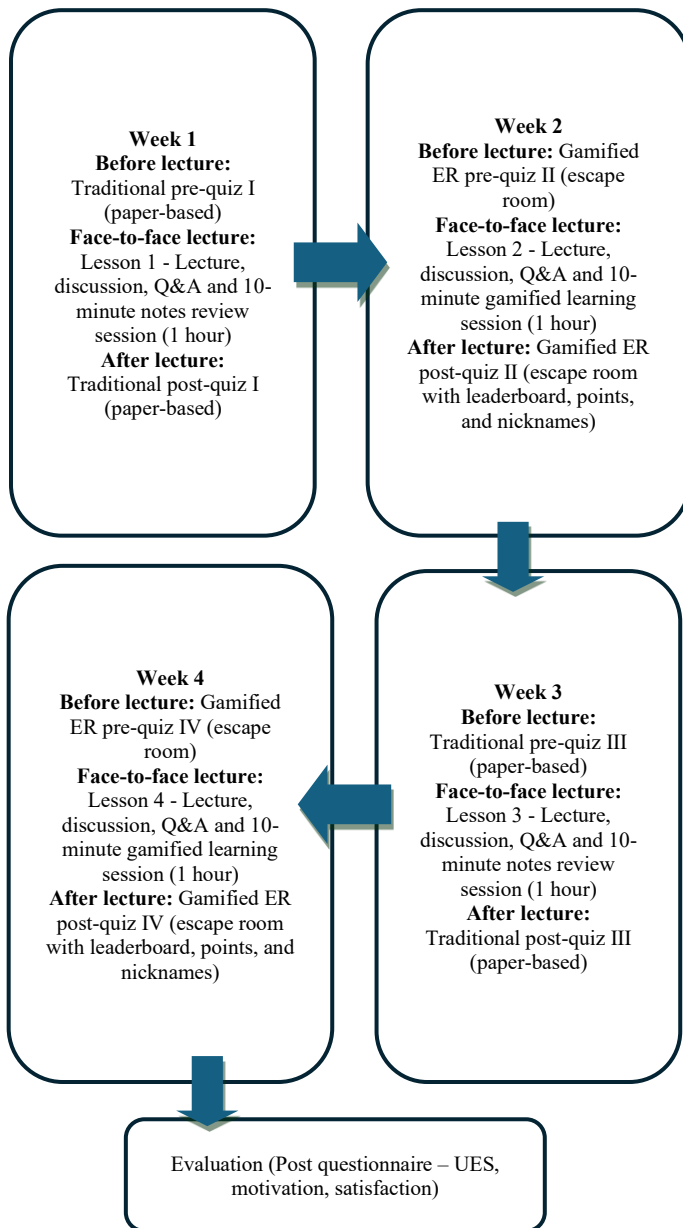


Fig. 1. Study design.

The pre- and post-quizzes alternated between traditional paper-based and gamified ER-based quizzes across the weeks to allow comparison. The quizzes were designed to have comparable levels of difficulty across both formats. Quantitative data were collected from the pre- and post-quiz scores to measure students' learning performance.

In addition, a post-intervention questionnaire was conducted after the Gamified ER post-quiz IV (Week 4) to evaluate student engagement and satisfaction across the different learning tools. The learner engagement data were also collected using the adapted User Engagement Scale (UES) developed by O'Brien et al. [17]. The UES assesses engagement across four constructs: Focused Attention (FA), Perceived Usability (PU), Aesthetic Appeal (AE), and Reward Factor (RW). The items were measured using a 5-point Likert scale ranging from strongly disagree to strongly agree. The collected evaluation data were analysed using descriptive statistics to summarise engagement levels across the UES dimensions. Furthermore, the reliability of the adapted UES was evaluated using Cronbach's alpha, following the approach adopted by Amriza et al. [18].

III. GAMIFIED PLATFORM

A. Gamification Elements

Building on previous research that identified common gamification elements in educational settings [15, 19, 20], this study integrated several features to boost student motivation and engagement. Specifically, the gamification elements included a leaderboard, escape room challenge, background music, points system, and digital certificates. These features were embedded within the gamification learning platform and deployed during the in-class gamified ER-based quiz sessions. The escape room activity served as the core interactive component, where students solved database subject-related challenges. Background music, which could be turned on or off by the students, provided an immersive and stimulating environment. Points were awarded based on task completion and accuracy, and students' cumulative scores were reflected in a dynamic leaderboard visible to all participants. This encouraged healthy competition among peers. To preserve anonymity and promote fairness, students participated under nicknames rather than real names. At the end of the session, students received digital certificates as recognition of their performance. Their ranking position and the top three scores remained visible on the gamification learning platform until the next scheduled activity to provide sustained motivation and a sense of accomplishment.

B. Gamified Learning Session

As illustrated in Fig. 2 and Fig. 3, the gamified learning session was designed as an engaging learning activity to reinforce key concepts covered in the database course. The session consisted of 10 interactive questions delivered through a game-based interface. The question types varied and included MCQs, true or false, and fill-in-the-blank formats. This variety aimed to support content recall and conceptual understanding through active participation. The interface featured a visually immersive environment with game-like elements such as a score tracker and a themed background. The session served as a preparatory activity before students advanced to the escape room quiz, which offered further opportunities to apply their knowledge in a more challenging and problem-solving context.

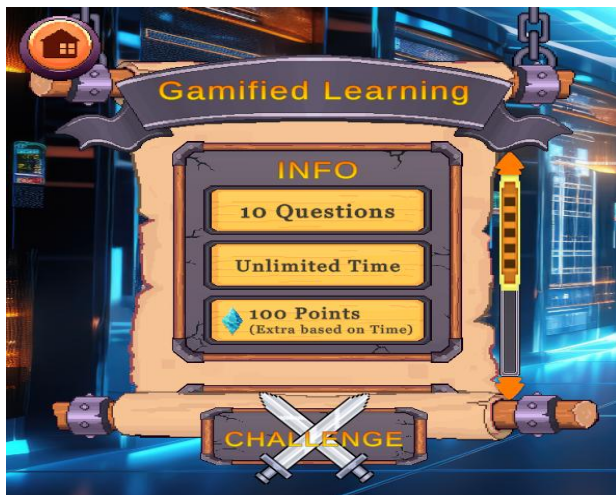


Fig. 2. Gamified learning platform.

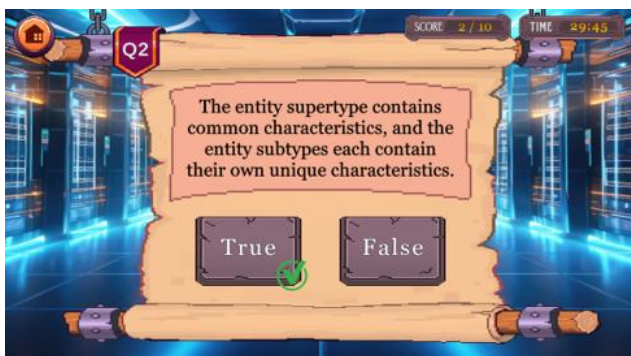


Fig. 3. Gamified learning question.

C. Escape Room

The escape room approach in education is a modern pedagogical strategy designed to motivate students through immersive and interactive learning experiences. Prior studies have demonstrated its effectiveness in enhancing learning across subjects such as Mathematics [21,22]. Drawing inspiration from these, the gamified escape room in this study integrates goal-setting, game characters, interactive tasks, feedback, problem-solving, and a fun learning environment.



Fig. 4. Gabriel, the adventurer, enters the castle to seek treasure.

As illustrated in Fig. 4, the storyline begins with Gabriel, the adventurer, entering the Golden Dragon's Castle in search

of treasure. Students solve database challenges to help Gabriel progress through the escape room adventure.



Fig. 5. Escape Room (ER) page.

Fig. 5 shows the escape room setting where learners engage with the environment to unlock clues and progress in the game. Each challenge is tied to database concepts, encouraging students to analyze clues, recall lesson content, and apply knowledge in a meaningful way, which mirrors the real-world problem-solving in database design (see Fig. 6). After completing each challenge, students receive a clue that helps them unravel the final escape code.



Fig. 6. Gamified ER-based quiz.

IV. RESULTS

A. Student Learning Performance

The findings of this study reveal that the gamified escape room learning activity significantly enhanced students' learning performance compared to the traditional paper-based quiz activity. All students participated in both activities, enabling a within-subject comparison of their performance.

TABLE I. WILCOXON SIGNED-RANK TEST FOR COMPARING STUDENTS' ACHIEVEMENTS BETWEEN PAPER-BASED AND GAMIFIED ESCAPE ROOM-BASED POST-QUIZZES

Quizzes	N	Wilcoxon Signed-Rank Test			
		Mean	W-value	z-score	p-value
Paper-based quiz I	200	80.58	172.50	10.85	< .001
Gamified ER-based quiz II	200	98.67			
Paper-based quiz III	200	85.17	0.00	9.42	< .001
Gamified ER-based quiz IV	200	99.83			

As shown in Table I, the Wilcoxon Signed-Rank test results indicated statistically significant differences in student scores between the two types of learning activities. Following the face-to-face lecture in Lesson 1, which included a lecture, discussion, question-and-answer session, and a short 10-minute notes review, students completed the Paper-based Post-Quiz I. The mean score obtained for this post-quiz was 80.58. In contrast, in Week 2, the face-to-face lecture for Lesson 2 incorporated a 10-minute gamified learning session, discussion, and question-and-answer activities, followed by gamified ER Post-Quiz II. The mean score increased to 98.67, which was significantly higher than the paper-based Post-Quiz I mean score of 80.58 ($W = 172.50$, $z = 10.85$, $p < .001$). A similar trend was observed in Weeks 3 and 4, where the paper-based Post-Quiz III (Lesson 3) produced a mean score of 85.17, whereas the gamified ER Post-Quiz IV achieved a significantly higher mean score of 99.83 ($W = 0$, $z = 9.42$, $p < .001$).

On average, students completed the escape room challenge in approximately six minutes. These results underscore the added instructional value of combining gamified learning with interactive activities like escape rooms, compared to traditional passive review.

TABLE II. COMPARISON OF STUDENTS' PRE- AND POST-QUIZ PERFORMANCE FOR PAPER-BASED AND GAMIFIED ESCAPE ROOM-BASED QUIZZES

Quizzes	N	Pre-Quiz			Post-Quiz		
		Mean	SD	Median	Mean	SD	Median
Paper-based quiz I	20	23.83	16.7	16.6	80.58	16.3	83.3
Gamified ER-based quiz II	20	27.58	16.2	33.3	98.67	4.52	83.3
Paper-based quiz III	20	25.25	15.9	16.6	85.17	14.7	100
Gamified ER-based quiz IV	20	34.42	14.1	33.3	99.83	1.66	100

Further evidence can be seen in the pre- and post-quiz descriptive statistics in Table II. Students began with similar pre-quiz medians (16.67 to 33.33), reflecting comparable baseline knowledge. After the learning sessions, post-quiz medians increased substantially, reaching 83.33 for both Quiz I and Quiz II, and 100 for Quiz III and Quiz IV. Additionally, the standard deviations were lower in the gamified ER-based quiz activities (e.g., $SD = 4.52$ for Quiz II and 1.66 for Quiz IV), indicating more consistent performance, possibly due to the motivational and interactive elements embedded in the gamified learning environment.

These quantitative findings were further reinforced through student perceptions. All respondents expressed high levels of satisfaction with escape room learning and recommended it as a supplementary tool for juniors in database courses. All students indicated a preference for the gamified ER-based quizzes approach over the conventional paper-based quizzes. They cited its greater satisfaction, motivation and effectiveness during class activities. This makes us believe that interactive and gamified learning is not just effective in terms of academic performance but is also well-accepted and pedagogically impactful.

B. Student Engagement and Experience

After the gamified ER post-quiz IV, all participants completed the UES O'Brien et al. [17] to evaluate their experience with the gamified ER-based quiz activities (see Appendix- Table VI). The questionnaire items use a 5-point Likert scale (1 "Strongly Disagree" to 5 "Strongly Agree"). The UES evaluates four engagement dimensions: Focused Attention (FA), Perceived Usability (PU), Aesthetic Appeal (AE), and Reward (RW).

To assess the UES evaluation results, the response values for the UES items PU.1, PU.2, PU.3, PU.4, PU.5, PU.6, PU.8, and RW.3 were reverse-coded before analysis [23]. Then, descriptive statistics were calculated to summarize participants' responses for each item, including the mean, standard deviation (SD), minimum, median, maximum, and mode. As shown in Table III, the mean scores across all constructs were high, ranging from 4.41 to 4.74. These high mean scores indicate a high level of student engagement with the Gamified ER-based quiz activities. Most items also recorded a mode of 5, in which the majority of participants strongly agreed with the statements related to engagement, usability, visual appeal, and perceived reward for the activity. These findings suggest that the gamified escape room design effectively supported active participation, high engagement, and positive learning experiences among students.

TABLE III. DESCRIPTIVE STATISTICS OF UES EVALUATION RESULTS (N = 200). ITEMS WERE RATED ON A 5-POINT LIKERT SCALE (1 = STRONGLY DISAGREE, 5 = STRONGLY AGREE)

UES	Mean	SD	Min	Mdn	Max	Mode	N for Mode
FA.1	4.69	0.46	4	5	5	5	138
FA.2	4.62	0.62	2	5	5	5	133
FA.3	4.61	0.62	2	5	5	5	132
FA.4	4.61	0.67	2	5	5	5	135
FA.5	4.56	0.74	2	5	5	5	132
FA.6	4.61	0.57	2	5	5	5	128
FA.7	4.6	0.63	2	5	5	5	129
PU.1	4.53	0.58	2	5	5	5	113
PU.2	4.41	0.67	2	4	5	5	97
PU.3	4.44	0.6	2	4	5	4	100
PU.4	4.46	0.6	2	5	5	5	100
PU.5	4.49	0.6	2	5	5	5	106
PU.6	4.49	0.57	2	5	5	5	103
PU.7	4.61	0.59	2	5	5	5	129
PU.8	4.46	0.6	2	4	5	5	99
AE.1	4.74	0.44	4	5	5	5	147
AE.2	4.71	0.45	4	5	5	5	142
AE.3	4.69	0.55	2	5	5	5	144
AE.4	4.68	0.56	2	5	5	5	143
AE.5	4.63	0.55	2	5	5	5	131
RW.1	4.46	0.68	2	5	5	5	105
RW.2	4.64	0.49	3	5	5	5	128

RW.3	4.45	0.61	2	4	5	5	99
RW.4	4.59	0.63	2	5	5	5	128
RW.5	4.66	0.57	2	5	5	5	139
RW.6	4.68	0.58	2	5	5	5	143
RW.7	4.64	0.54	2	5	5	5	131
RW.8	4.68	0.5	2	5	5	5	137
RW.9	4.63	0.54	2	5	5	5	130
RW.10	4.67	0.56	2	5	5	5	139

Note: SD = standard deviation; Min = minimum; Mdn = median; Max = maximum

C. Reliability Analysis and Descriptive Statistics

Reliability analysis and descriptive statistics were conducted to assess the reliability of each UES scale. As shown in Table IV, all constructs demonstrated good internal consistency, with Cronbach's alpha values ranging from 0.840 to 0.913. The mean scores for the UES scales were also relatively high, ranging from 4.484 to 4.689. Among the dimensions, AE recorded the highest mean score (Mean = 4.689), followed by RW (Mean = 4.607), FA (Mean = 4.612), and PU (Mean = 4.484). These results suggest that students perceived the gamified ER activity as visually appealing, rewarding, and capable of sustaining their attention. The relatively small standard deviations further indicate that the responses were consistent across participants. Overall, the

findings show positive student engagement in the gamified ER activity. It also demonstrates that the UES scales are reliable measures for evaluating different dimensions of student engagement.

D. Validity Analysis

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were further conducted to examine the factor structure. As shown in Table V, the results supported a four-factor model consisting of FA, PU, AE, and RW. All factor loadings were high and statistically significant ($p < .001$), indicating that the UES questionnaire is a reliable instrument for measuring student engagement in the gamified ER environment.

TABLE IV. RELIABILITY ANALYSIS AND DESCRIPTIVE STATISTICS

UES	No Items	Cronbach's Alpha	Mean	Standard Deviation
Focused Attention (FA)	7	0.840	4.612	0.445
Perceived Usability (PU)	8	0.913	4.484	0.476
Aesthetic Appeal (AE)	5	0.903	4.689	0.438
Reward (RW)	10	0.881	4.607	0.399

TABLE V. FACTOR LOADINGS OF THE GAMIFIED ER WITH 1-FACTOR EXPLORATORY MODEL AND WITH 4-FACTOR CONFIRMATORY MODEL

Factor		Exploratory Factor Analysis (EFA)	4-factor Confirmatory Factor Analysis (CFA)					
			FA	PU	AE	RW	z-score	p-value
Focused Attention (FA)	FA.1	0.850	0.869				25.805	< .001
	FA.2	0.921	0.861				31.983	< .001
	FA.3	0.893	0.796				23.726	< .001
	FA.4	0.810	0.757				18.748	< .001
	FA.5	0.858	0.827				25.073	< .001
	FA.6	0.684	0.879				30.290	< .001
	FA.7	0.607	0.860				25.901	< .001
Perceived Usability (PU)	PU.1	0.849		0.830			28.275	< .001
	PU.2	0.893		0.871			40.602	< .001
	PU.3	0.953		0.953			63.849	< .001
	PU.4	0.920		0.975			56.664	< .001
	PU.5	0.921		0.925			49.931	< .001
	PU.6	0.883		0.926			53.988	< .001
	PU.7	0.467		0.567			8.716	< .001
	PU.8	0.891		0.855			34.431	< .001
Aesthetic Appeal (AE)	AE.1	0.874			0.951		63.424	< .001
	AE.2	0.872			0.937		59.547	< .001
	AE.3	0.961			0.951		70.568	< .001
	AE.4	0.913			0.952		47.846	< .001
	AE.5	0.936			0.957		64.474	< .001
Reward (RW)	RW.1	0.570				0.636	13.771	< .001
	RW.2	0.923				0.924	46.104	< .001

	RW.3	0.519				0.653	14.906	< .001
	RW.4	0.872				0.852	30.538	< .001
	RW.5	0.785				0.778	25.107	< .001
	RW.6	0.805				0.757	21.714	< .001
	RW.7	0.884				0.873	35.082	< .001
	RW.8	0.880				0.900	47.036	< .001
	RW.9	0.905				0.921	44.950	< .001
	RW.10	0.903				0.906	39.562	< .001

V. DISCUSSION

These findings are consistent with previous research highlighting the benefits of gamified instructional approaches in higher education settings. Zainuddin et al. [24] emphasized that integrating interactive and competitive elements through gamification can enhance learning outcomes. In the present study, the use of escape room-based quizzes enabled students to engage with database concepts in a simulated and challenge-driven environment that mirrored active learning principles. The gamified activities likely helped students score higher in both gamified sessions (Quiz II and Quiz IV). This pattern was also observed in a similar study by Gordillo and López-Fernández [25], which demonstrated increased knowledge acquisition and improved student perceptions in software engineering education through escape rooms.

The reduced standard deviations in the gamified ER-based quiz results ($SD = 4.52$ and 1.66) suggest that students performed more consistently compared to the traditional paper-based quizzes. This indicates that the escape room may have been particularly effective in supporting students who typically struggle in conventional learning settings. By embedding course content within an interactive game scenario that included points, nicknames, feedback, and leaderboards, the learning activities promoted motivation and knowledge retention. This finding is consistent with Welbers et al. [26], who demonstrated the potential of gamification to enhance student engagement in learning activities. Recent work by Mauri-Medrano et al. [27] also found that students exposed to escape room learning showed increased levels of fun and creative thinking that align closely with our observed results.

Aligned with the work of Lampropoulos and Kapoula [28] and Gerber and Fischetti [29], these findings reinforce the value of gamification in transforming passive content delivery into interactive and problem-solving experiences. In this study, the escape room tasks were designed to reflect core learning objectives from the database course, complemented by a short gamified learning session before the ER quizzes. Furthermore, students received immediate feedback during the gamified escape room activities and could identify errors in their responses. The paper-based quizzes did not provide this immediate feedback. This learning activity likely enhanced student motivation and knowledge retention, as reflected in the significantly higher post-quiz means from the gamified ER-based sessions (98.67 and 99.83) compared to the paper-based counterparts (80.58 and 85.17).

Moreover, the students' feedback obtained during Week 4 further supports the quantitative results. All students reported

being very satisfied with the Escape Room activity and recommended it for future use. The preference of all students towards the gamified method rather than the paper-based quiz reflects its perceived effectiveness and demand in enhancing classroom learning activities.

Furthermore, the students reported high engagement across all UES dimensions. The elements in the gamified ER, such as leaderboards, nicknames, and points, likely increased students' motivation and active participation. This finding is consistent with Wiebe et al. [30], in which the work reported that higher engagement levels in game-based environments are associated with improved performance outcomes.

In summary, these outcomes support the use of escape rooms integrated with gamification concepts as an effective pedagogical tool. In addition to reinforcing conceptual understanding, this approach also fosters student motivation and encourages equitable participation, which are important contributors to academic success and sustained motivation in learning.

VI. CONCLUSION

This study demonstrates that gamified ER-based quiz activities can significantly enhance students' learning performance, motivation, and engagement in higher education, particularly in content-intensive subjects like database design. The within-subject design allowed students to experience both traditional and gamified approaches, and the results clearly showed higher post-quiz scores in the gamified sessions. The integration of game elements such as points, nicknames, and leaderboards provided an engaging, competitive, and immersive environment that supported knowledge retention and active learning. The user experience findings also indicate that students responded positively to both the practical and experiential aspects of the activity. High ratings for focused attention, perceived usability, aesthetic appeal, and reward are in line with the established four-factor structure of the UES, which has been shown to have good reliability and validity. Aesthetic appeal received the strongest evaluation, suggesting that visually appealing and interactive design features play an important role in sustaining engagement. This fits prior research showing that aesthetic appeal is one of the most stable engagement dimensions, while enjoyable and activating escape-room experiences are consistently associated with stronger student participation and positive learning perceptions. Moreover, the consistent preference for the gamified quizzes over traditional methods highlights the effectiveness of interactive learning designs in fostering student participation and a high level of engagement. These findings are consistent

with previous research, which supports the use of gamification as an effective pedagogical tool for enhancing student engagement. They align with the growing need to transform conventional assessments into dynamic learning experiences that encourage self-directed learning. Therefore, educators are encouraged to explore and implement gamified strategies like escape rooms to enrich instructional delivery, improve learning outcomes, and support 21st-century educational goals.

VII. LIMITATIONS AND FUTURE WORK

This study was conducted among undergraduate students enrolled in a database course at a single institution, which limits the generalizability of the findings. Future research should involve multiple institutions and educational contexts to examine the broader applicability of the gamified escape room approach. Longer-term studies could assess its effects on knowledge retention and sustained student engagement. Future research could also examine the individual contributions of immediate feedback, points, and leaderboards to determine which elements most effectively support learning.

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APPENDIX

TABLE VI. UES ITEMS

Item	UES
AE.1	This Application X was attractive.
AE.2	This Application X was aesthetically appealing.
AE.3	I liked the graphics and images of Application X.
AE.4	Application X appealed to my visual senses.
AE.5	The screen layout of Application X was visually pleasing.
FA.1	I lost myself (deeply focused) in this experience.
FA.2	I enjoyed the experience of using Application X that I lost track of time.
FA.3	I blocked out activities around me when I was using Application X.
FA.4	When I was using Application X, I lost track of the world around me.
FA.5	The time I spent using Application X just slipped away.

FA.6	I was absorbed (interested) in this experience.
FA.7	During this experience I let myself enjoy it.
PU.1	I felt frustrated while using this Application X.
PU.2	I found this Application X confusing to use.
PU.3	I felt annoyed while using Application X.
PU.4	I felt discouraged while using this Application X.
PU.8	I could not do some of the things I needed to do while using Application X.
PU.5	Using this Application X was tiring.
PU.6	This experience of Application X browsing is troublesome.
PU.7	I felt in control while using this Application X.
RW.1	Using Application X was worthwhile.
RW.2	I consider my experience a success.
RW.3	This experience did not work out the way I had planned.
RW.4	My experience was rewarding.
RW.5	I would recommend Application X to my peers and friends.
RW.6	I continued to use Application X out of curiosity.
RW.7	The content of Application X sparked my interest.
RW.8	I am really interested into this experience.
RW.9	I felt involved in this experience.
RW.10	This experience was fun.