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The Impact of Gamification Elements on Student Engagement and Knowledge Retention in Distance Computer Education

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الملخص:

شهد التعليم العالي تحولاً سريعاً نحو التعلم الإلكتروني والتعلم المدمج خلال جائحة كوفيد-19، مما أبرز تحديات تتعلق بانخفاض دافعية الطلاب وضعف المشاركة، خاصة في مقررات علوم الحاسوب والبرمجة. وفي هذا السياق برز التلعيب (Gamification) كاستراتيجية مبتكرة لتعزيز التفاعل وتحسين نواتج التعلم. هدفت هذه الدراسة إلى استكشاف أثر دمج عناصر التلعيب في بيئة تعليمية عن بُعد لعلوم الحاسوب على أبعاد التحفيز والمشاركة والتفاعل ونواتج التعلم، مع تحديد العناصر الأكثر تأثيراً في تعزيز الدافعية والاحتفاظ بالمعرفة. واعتمدت الدراسة على استبيان وُزع على عينة مكونة من (25) طالباً، وتم تحليل البيانات باستخدام المتوسطات الحسابية والانحرافات المعيارية واختبار كاي تربيع (Chi-Square) لقياس دلالة الفروق بين التوزيع الفعلي والمتوقع للاستجابات. أظهرت النتائج أن 68% من الطلاب أكدوا أن التلعيب زاد من اهتمامهم بالمادة، في حين أشار 92% إلى أن نظام المكافآت حفّزهم على إكمال التكليفات البرمجية. كما أفاد 80% من المشاركين بشعورهم بالتركيز والانغماس أثناء الأنشطة الملعبة، وساعد التلعيب 80% منهم على التغلب على مشاعر العزلة المرتبطة بالتعلم عن بُعد. وكان لتخصيص الشخصيات الافتراضية (Avatar) التأثير الأكبر في تعزيز الاستقلالية بنسبة 92%، تلتها الشارات (Badges) بنسبة 88%. كذلك أكد 80% من الطلاب أن التحديات الملعبة ساعدتهم على تحسين مهارات حل المشكلات البرمجية، بينما بلغت نسبة الرضا عن سهولة استخدام المنصة 72%. وأظهرت المتوسطات الحسابية أن محور المشاركة والتفاعل جاء في المرتبة الأولى بمتوسط (4.35)، يليه التحفيز والاهتمام بمتوسط (4.20)، ثم عناصر التلعيب بمتوسط (4.12)، وأخيراً نواتج التعلم بمتوسط (4.08). كما بين اختبار كاي تربيع وجود فروق ذات دلالة إحصائية لجميع العبارات عند مستوى الدلالة ($\alpha \leq 0.05$) وتؤكد هذه النتائج أن دمج عناصر التلعيب في منصات التعلم الإلكتروني يُعد استراتيجية فعالة لتعزيز الدافعية والمشاركة وتحسين نواتج التعلم في مقررات علوم الحاسوب، كما أن عناصر مثل الشخصيات الافتراضية والشارات أثبتت فاعلية عالية في دعم الاستقلالية والشعور بالإنجاز، مما يدعم دمج التلعيب بصورة منهجية في تصميم المقررات الإلكترونية بما يتوافق مع متطلبات التحول الرقمي في التعليم العالي.

الكلمات المفتاحية :التلعيب، تعليم علوم الحاسوب، التعلم عبر الإنترنت، مشاركة الطلاب، الدافعية، مهارات حل المشكلات، التحول الرقمي.

Abstract

Higher education experienced a rapid shift toward online and blended learning during the COVID-19 pandemic, exposing challenges related to declining student motivation, limited engagement, and feelings of isolation, particularly in computer science and programming courses. In this context, gamification emerged as an innovative approach to enhance interaction and improve learning outcomes. This study investigated the impact of integrating gamification elements into remote computer science education, focusing on motivation, engagement, interaction, and learning outcomes, while identifying the most influential gamification components in promoting motivation and knowledge retention. A survey was administered to a sample of 25 students, and the collected data were analyzed using descriptive statistics, including means and standard deviations, as well as the Chi-Square test to examine the significance of differences between observed and expected responses. The findings revealed that 68% of students reported increased interest in the subject due to gamification, while 92% indicated that reward systems motivated them to complete programming assignments. Moreover, 80% of participants experienced immersion and focus during gamified activities, and the same percentage reported reduced feelings of isolation associated with remote learning. Avatars demonstrated the strongest influence on

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autonomy (92%), followed by badges (88%), which reinforced achievement and motivation. In addition, 80% of students stated that gamified challenges improved their programming problem-solving skills, while 72% expressed satisfaction with the platform's ease of use. The mean scores showed that the engagement and interaction dimension ranked first (4.35), followed by motivation and interest (4.20), gamification elements (4.12), and learning outcomes (4.08). Chi-Square analysis also indicated statistically significant differences across all survey items at the significance level ($\alpha \leq 0.05$). These results confirm that gamification is an effective pedagogical strategy for enhancing motivation, engagement, and learning outcomes in remote computer science education. Furthermore, elements such as avatars and badges proved particularly effective in fostering autonomy and a sense of achievement, supporting the systematic integration of gamification into digital learning environments in line with the ongoing digital transformation of higher education.

Keywords: *Gamification, Computer Science Education, Online Learning, Student Engagement, Motivation, Problem-Solving Skills, Digital Transformation.*

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1. Introduction

The COVID-19 pandemic triggered a rapid and dramatic transformation in higher education systems worldwide, compelling academic institutions to adopt online and blended learning models to ensure the continuity of educational processes during crises (Ahmed et al., 2025; Khaleel et al., 2020). Although the integration of technology into education is not a new phenomenon, the extensive reliance on Learning Management Systems (LMSs) revealed significant challenges related to declining student motivation, reduced academic engagement, and increasing feelings of isolation and digital fatigue resulting from the absence of face-to-face interaction (Ahmed et al., 2025; Chans & Castro, 2021; Raju et al., 2021). These challenges have encouraged researchers to explore innovative approaches such as gamification to enhance interaction and overcome the limitations of traditional remote teaching methods (Ahmed et al., 2025; Dawson et al., 2025). These issues are particularly pronounced in Science, Technology, Engineering, and Mathematics (STEM) disciplines, especially Computer Science, where programming courses are widely regarded as among the most challenging subjects for students due to their theoretical complexity and the intensive practice required for mastery (Khaleel et al., 2020; Zahedi et al., 2019). Statistics indicate that failure and withdrawal rates in programming-related courses range from 35% to 50%, largely due to loss of interest and difficulties in comprehending abstract concepts (Khaleel et al., 2020; Umasangadji et al., 2025). Furthermore, a noticeable gender disparity persists in the field, with female participation in Computer Science remaining below desired levels, highlighting the need for instructional strategies capable of attracting and retaining diverse student populations (Zahedi et al., 2019). In this context, gamification is defined as the application of game elements, mechanics, and design principles in non-game environments to promote desirable behaviors and outcomes (Ahmed et al., 2025; Alsawaier, 2018; Zahedi et al., 2019). Gamification elements commonly include points, badges, leaderboards, levels, quests, avatars, and immediate feedback mechanisms (Ahmed et al., 2025; Chans & Castro, 2021; Zahedi et al., 2019). Collectively, these elements aim to transform

educational content from a static body of information into an immersive and interactive learning experience that enhances students' attention, participation, and commitment to learning activities (Ahmed et al., 2025; Chans & Castro, 2021). The effectiveness of gamification is grounded in well-established psychological and educational theories, most notably Keller's ARCS Model (Attention, Relevance, Confidence, and Satisfaction) and Self-Determination Theory (SDT) (Chans & Castro, 2021; Umasangadji et al., 2025; Alsawaier, 2018). These theoretical frameworks suggest that successful gamification depends on fulfilling learners' fundamental psychological needs, namely competence through feelings of achievement, autonomy through freedom of choice, and relatedness through collaboration and social interaction with peers (Umasangadji et al., 2025; Alsawaier, 2018). Gamification is also closely associated with Flow Theory, which emphasizes maintaining an optimal balance between task difficulty and learner skills to facilitate deep engagement and immersion in learning activities. Recent empirical studies have reported promising outcomes for gamified learning environments. In Computer Science education, gamification has been shown to significantly improve students' understanding of concepts such as Object-Oriented Programming (OOP) when compared with traditional learning platforms (Ahmed et al., 2025; Khaleel et al., 2020). Research further indicates that students participating in gamified educational platforms, particularly those based on Gamified Mobile and Cloud Learning Management Systems (GMCLMS), demonstrate higher levels of satisfaction and academic achievement (Ahmed et al., 2025). Moreover, the benefits of gamification extend beyond immediate performance, contributing to improved knowledge retention for periods lasting several months after course completion (Umasangadji et al., 2025). Gamified environments also encourage students to practice programming without fear of failure by providing repeated opportunities for experimentation, error correction, and progressive improvement within an enjoyable learning framework (Khaleel et al., 2020; Raju et al., 2021). Despite these advantages, scholars have highlighted several challenges associated with the implementation of gamification. One notable concern is the novelty effect, whereby learners' initial enthusiasm may diminish over time if gamification elements are not supported by sound instructional design or closely aligned with academic objectives (Khaleel et al., 2020; Hanus & Fox, 2015). Additionally, excessive reliance on extrinsic rewards, such as points and badges alone, may produce counterproductive effects by undermining intrinsic motivation (Umasangadji et al., 2025; Ahmed et al., 2025). Technical and organizational barriers also exist, including the need for teacher training, financial investment, and the considerable time required to design and implement sophisticated gamified learning activities (Dawson et al., 2025; Umasangadji et al., 2025). Therefore, this study aims to develop and evaluate an integrated gamification model within a remote Computer Science learning environment and to investigate its impact on behavioral, cognitive, and emotional engagement. Particular emphasis is placed on achieving a balanced integration of game elements to ensure sustainable educational outcomes that align with contemporary technological and pedagogical requirements.

2. Research Methodology:

This study adopted a descriptive-analytical research approach to investigate the impact of integrating gamification elements into a remote Computer Science learning environment. An electronic questionnaire was developed consisting of a set of statements distributed across four main dimensions:

1. Motivation and Interest.

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2. Participation and Interaction.
3. Specific Gamification Elements.
4. Learning Outcomes and Ease of Use.

The questionnaire was administered to a purposive sample of 25 students enrolled in online programming courses. Data were collected and analyzed using the following statistical techniques:

- Means and Standard Deviations to identify students' attitudes toward gamification.
- Relative Weights to rank the dimensions according to their perceived importance.
- Chi-Square Test to examine the statistical significance of differences between the observed and expected response distributions and to verify that the findings reflected genuine trends toward gamification rather than random variations.

The collected data were statistically processed to determine the extent to which gamification elements contribute to enhancing students' motivation, participation, and learning outcomes within a remote Computer Science education environment.

Results and Data Analysis:

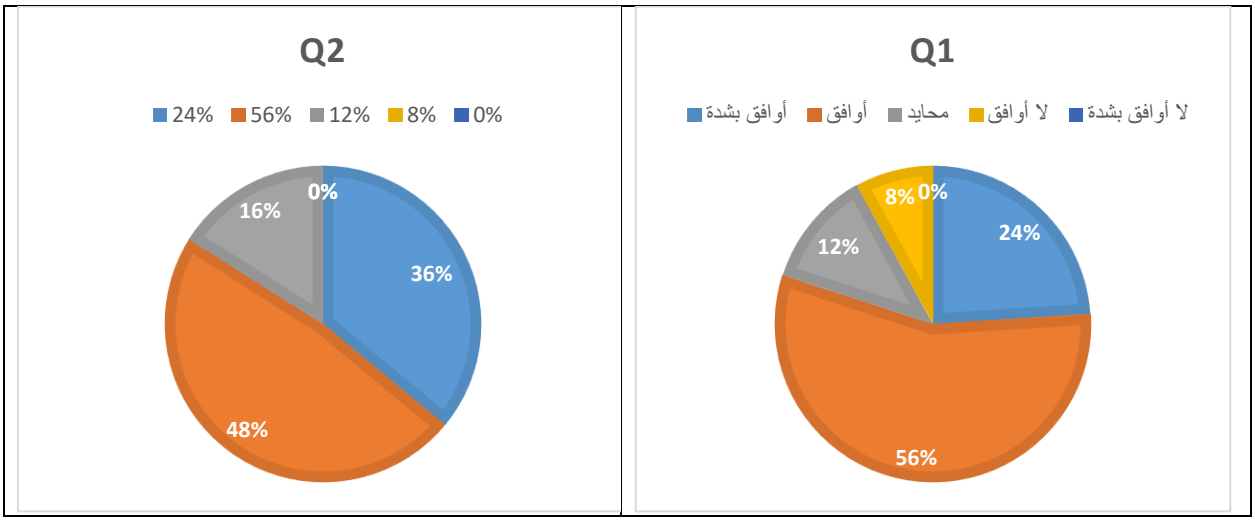
Responses were collected from a sample of 25 participants. The analysis yielded the following findings:

First: Motivation and Interest (*Motivation*):

3.Tables and Figures

Table 1. Percentage Distribution of Participants' Responses to the First Dimension Statements (Motivation and Interest) According to the Five-Point Likert Scale

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q1	24.0%	56.0%	12.0%	8.0%	0.0%
Q2	36.0%	48.0%	16.0%	0.0%	0.0%
Q3	24.0%	68.0%	8.0%	0.0%	0.0%
Q4	16.7%	62.5%	16.7%	4.1%	0.0%



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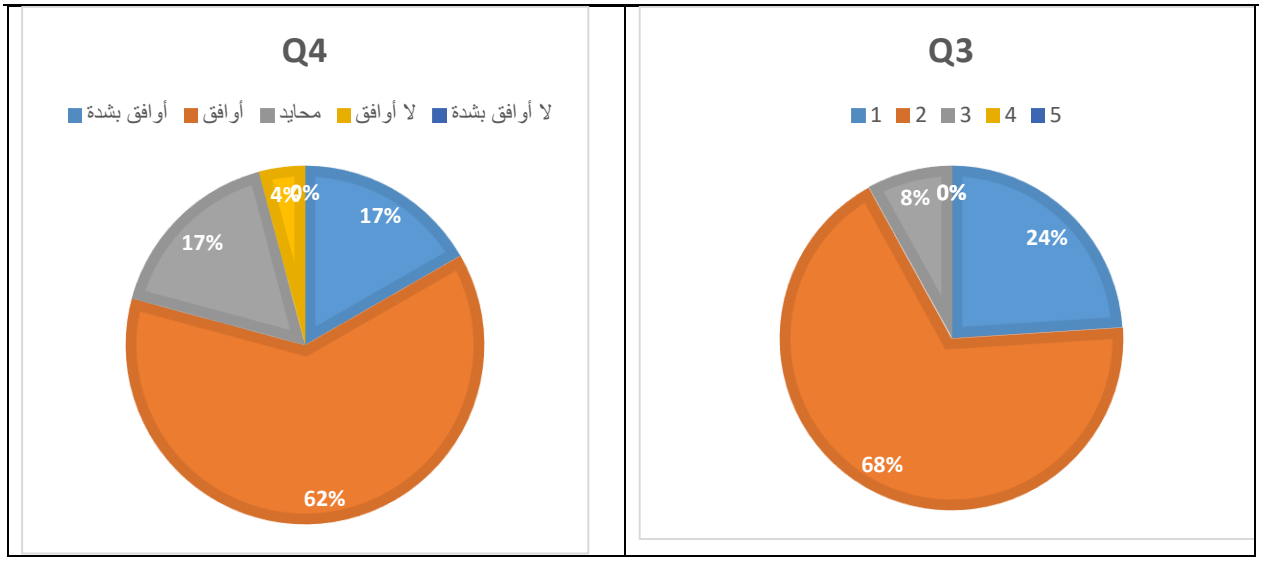

Figure 1. Percentage Distribution of Participants' Responses to the First Dimension Statements According to the Five-Point Likert Scale

The findings indicate that gamification contributed substantially to enhancing students' motivation. A majority of participants expressed positive perceptions toward the use of gamification, with 68% of students (combining the "Agree" and "Strongly Agree" categories) reporting that gamification increased their interest in the course content. Furthermore, the reward system demonstrated the strongest impact among the examined gamification elements, as 92% of respondents acknowledged its effectiveness in motivating them to complete programming assignments. These results suggest that gamified learning environments can play a significant role in fostering learner engagement and sustaining motivation in remote Computer Science education.

Second: Engagement and Interaction:

Table 2. Percentage Distribution of Participants' Responses to the Second Dimension Statements (Engagement and Interaction) According to the Five-Point Likert Scale

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q5	12.0%	80.0%	8.0%	0.0%	0.0%
Q6	48.0%	48.0%	0.0%	4.0%	0.0%
Q7	12.0%	68.0%	12.0%	8.0%	0.0%
Q8	24.0%	64.0%	12.0%	0.0%	0.0%

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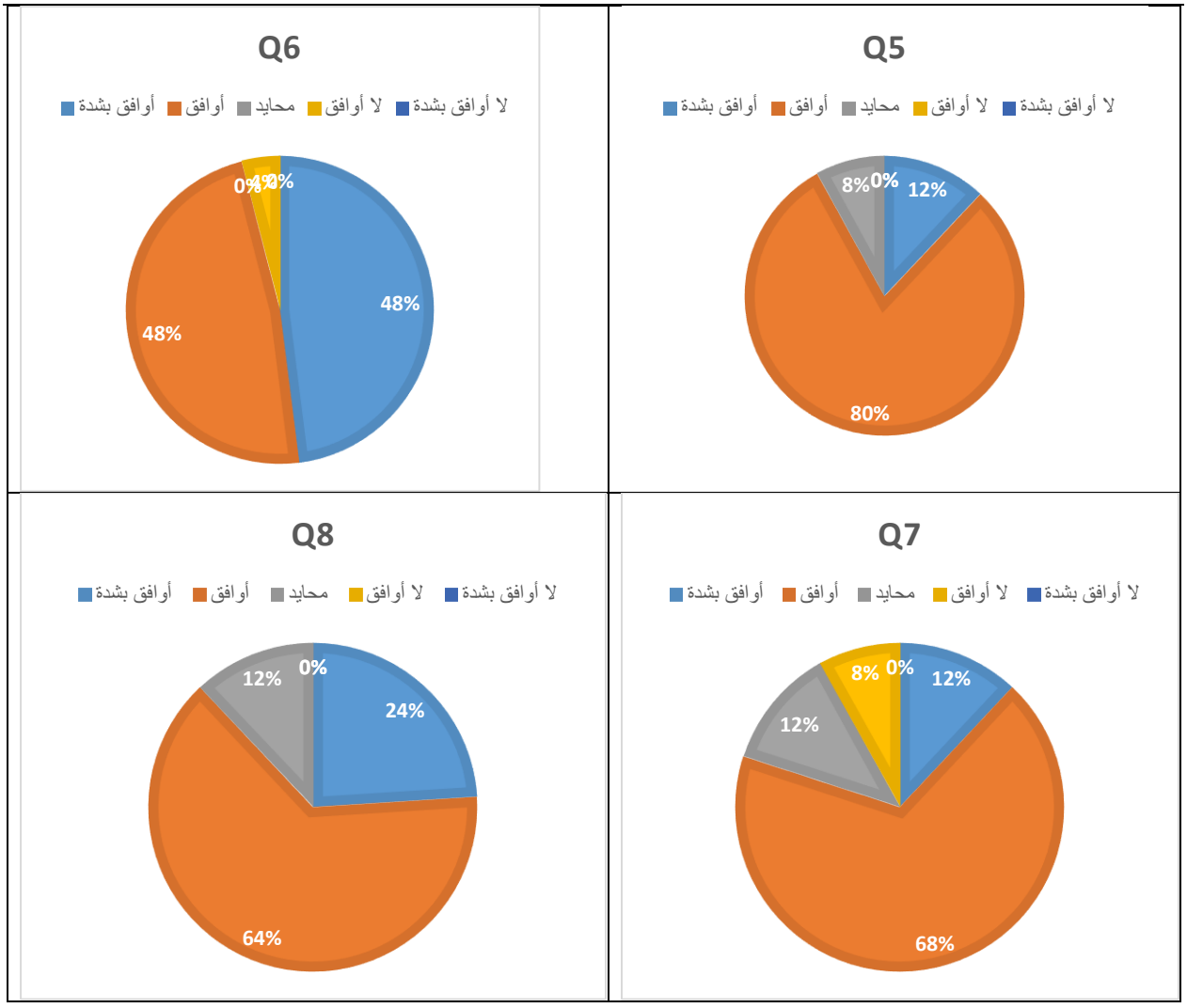

Figure 2. Percentage Distribution of Participants' Responses to the Second Dimension Statements According to the Five-Point Likert Scale

The results indicate a high level of student engagement within the gamified learning environment. Approximately 80% of participants reported experiencing a strong sense of concentration and immersion while completing gamified learning tasks, suggesting that gamification effectively captured students' attention and reduced distractions during the learning process. Furthermore, gamification demonstrated a significant social impact, with 80% of respondents indicating that it helped alleviate feelings of isolation commonly associated with remote learning. These findings highlight the potential of gamified learning environments to foster both cognitive engagement and social connectedness among students, thereby enhancing the overall online learning experience.

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Pages: 089 ~ 100

Table 3. Percentage Distribution of Participants' Responses Regarding the Impact of Gamification on Developing Problem-Solving and Analytical Thinking Skills

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q9	48.0%	32.0%	16.0%	4.0%	0.0%
Q10	28.0%	60.0%	12.0%	0.0%	0.0%
Q11	36.0%	52.0%	8.0%	4.0%	0.0%
Q12	4.0%	80.0%	12.0%	4.0%	0.0%

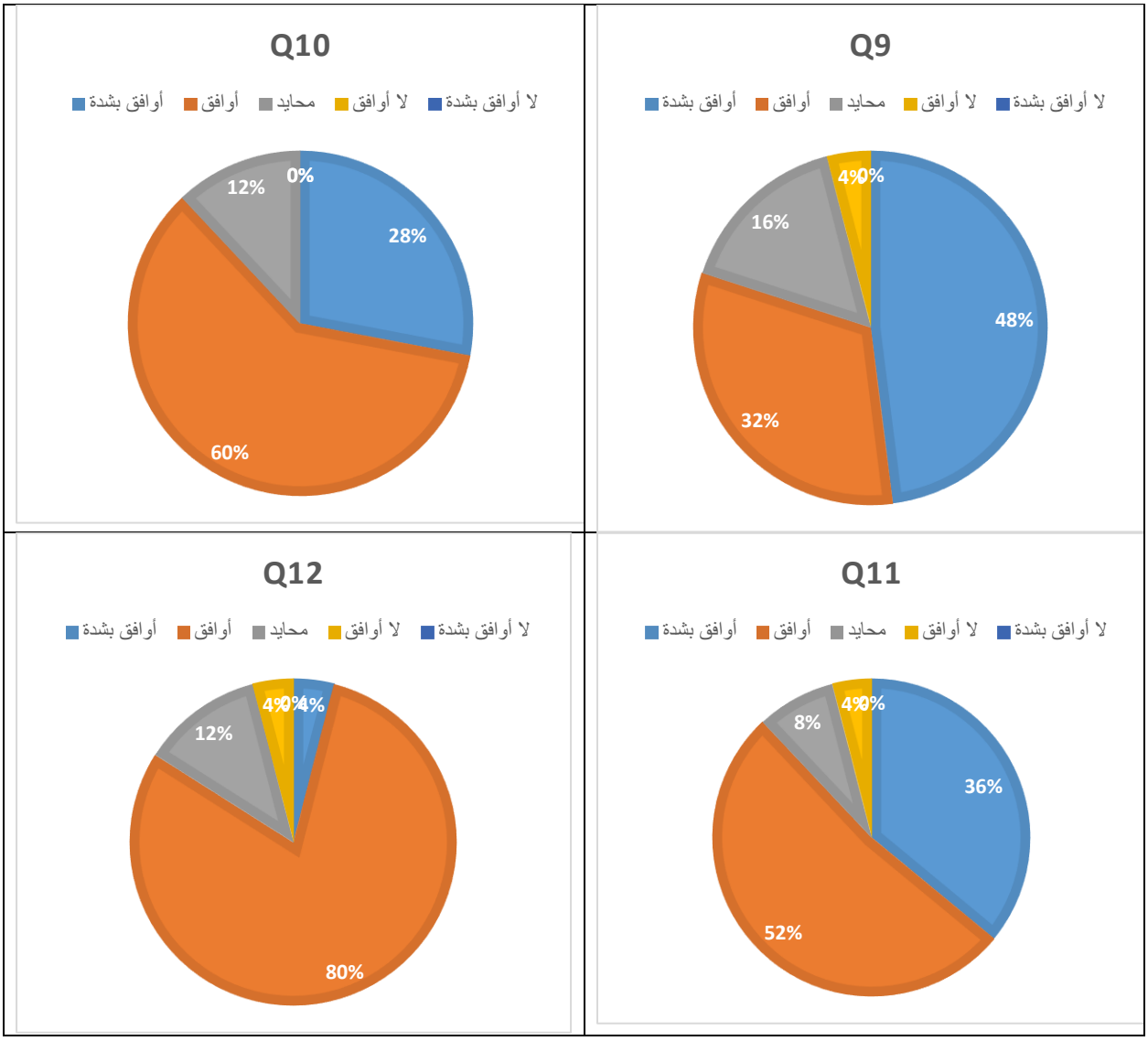

Figure 3. Percentage Distribution of Participants' Responses Regarding the Impact of Gamification on Developing Problem-Solving and Analytical Thinking Skills

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The results indicate that customizing avatars had the strongest impact on enhancing students' sense of autonomy, with a 92% approval rate, of which 80% strongly agreed. This suggests that allowing students to personalize their learning experience contributes significantly to fostering independence and engagement in learning activities. Badges ranked second with an 88% approval rate, reflecting their effectiveness in reinforcing students' sense of achievement and progress. These findings highlight the importance of personalized and reward-based gamification elements in supporting higher-order cognitive skills such as problem-solving and analytical thinking within remote Computer Science education environments.

Fourth: Learning Outcomes and Ease of Use:

Table 4. Percentage Distribution of Participants' Responses Regarding Overall Satisfaction with the Use of Gamification in the E-Learning Environment

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q13	20.0%	68.0%	12.0%	0.0%	0.0%
Q14	24.0%	60.0%	12.0%	0.0%	4.0%

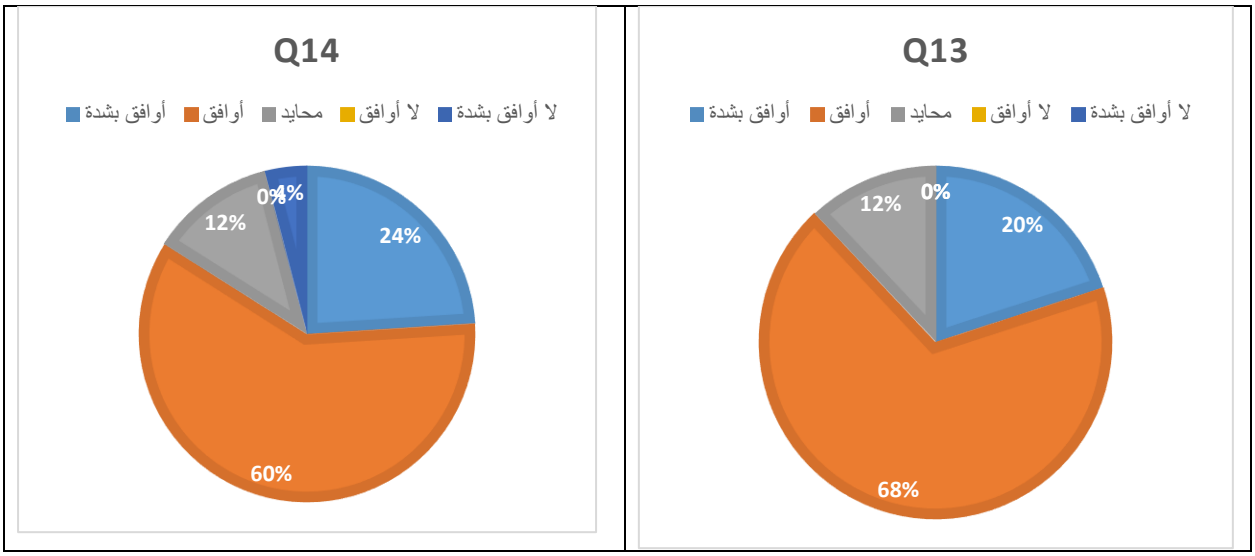

Figure 4. Percentage Distribution of Participants' Responses Regarding Overall Satisfaction with the Use of Gamification in the E-Learning Environment

The findings confirm the educational benefits of gamification within the online learning environment. Approximately 80% of participants agreed that gamified challenges contributed to improving their programming problem-solving skills, indicating that game-based activities can effectively support the development of critical thinking and computational problem-solving abilities. Furthermore, the platform's ease of use received favorable evaluations from students, facilitating flexible learning through cloud- and mobile-based environments. Overall, 72% of respondents expressed positive perceptions regarding the usability and accessibility of the platform. These results suggest that gamification not only enhances learning outcomes but also promotes a user-friendly learning experience, thereby increasing students' acceptance and continued engagement in remote Computer Science education.

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Table 5. Means, Standard Deviations, Relative Weights, and Ranking of Questionnaire Dimensions on the Impact of Gamification Elements on Student Engagement and Knowledge Retention in Remote Computer Science Education

Dimension	Mean	Standard Deviation	Relative Weight (%)	Rank
Engagement and Interaction	**4.35**	**0.61**	**87.0**	**1**
Motivation and Interest	**4.20**	**0.58**	**84.0**	**2**
Gamification Elements	**4.12**	**0.66**	**82.4**	**3**
Learning Outcomes	**4.08**	**0.63**	**81.6**	**4**

Table 6. Frequency Distribution of Observed and Expected Values and Chi-Square (χ^2) Values for Response Categories

Response Category	Observed (O)	Expected (E)	$(O - E)^2 / E$
Strongly Agree	**6**	**5**	**0.2**
Agree	**14**	**5**	**16.2**
Neutral	**3**	**5**	**0.8**
Disagree	**2**	**5**	**1.8**

Table 7. Chi-Square Test Results for the Significance of Participants' Responses Toward Questionnaire Items on the Impact of Gamification on Student Engagement and Knowledge Retention in Remote Computer Science Education

Item	Chi-Square (χ^2)	df	Asymp. Sig. (p-value)	Result
Question 1	24.00	4	0.000	Statistically significant
Question 2	23.20	4	0.000	Statistically significant
Question 3	40.80	4	0.000	Statistically significant
Question 4	29.75	4	0.000	Statistically significant
Question 5	57.60	4	0.000	Statistically significant
Question 6	32.80	4	0.000	Statistically significant
Question 7	37.20	4	0.000	Statistically significant
Question 8	35.20	4	0.000	Statistically significant
Question 9	44.80	4	0.000	Statistically significant
Question 10	20.00	4	0.000	Statistically significant
Question 11	31.60	4	0.000	Statistically significant
Question 12	26.00	4	0.000	Statistically significant

4. Discussion:

The results of the Chi-Square test indicate that all significance values (Sig.) were lower than 0.05, demonstrating statistically significant differences between the observed and expected distributions of responses. Accordingly, the participants' responses were not random but instead showed a clear tendency toward agreement with the questionnaire items. This reflects a positive impact of gamification elements in enhancing motivation, engagement, and learning outcomes in a remote Computer Science education environment. The findings of the present study revealed that the use of gamification elements significantly contributed to enhancing students' motivation and interest in remote Computer Science learning environments. Approximately 68% of the participants reported that gamification increased their interest in the course content, while 92% confirmed the motivating role of the reward system in encouraging them to complete programming assignments. These results suggest that incorporating gamification elements such as rewards and

immediate feedback effectively enhances learners' intrinsic motivation and increases their engagement in the learning process. This finding is consistent with Raju et al. (2021), who reported that gamification tools in e-learning environments improve student motivation, participation, and academic performance. It also aligns with Umasangadji et al. (2025), who emphasized that gamification addresses low learner motivation by supporting competence, autonomy, and intrinsic interest. The results further indicated a high level of student engagement and interaction, as 80% of respondents reported experiencing deep concentration and immersion during gamified learning activities. In addition, 80% of participants stated that gamification helped reduce feelings of isolation commonly associated with online learning. This can be explained by Raju et al. (2021), who argued that gamified learning environments enhance participation and sustain learner interaction. Similarly, Umasangadji et al. (2025) highlighted that clear progression systems, meaningful challenges, and immediate feedback mechanisms strengthen behavioral engagement and maintain continuous participation in learning activities. Regarding gamification elements, the findings showed that avatars were the most influential element in enhancing students' sense of autonomy, with a 92% agreement rate, followed by badges at 88%. This suggests that such elements provide learners with a sense of achievement and identity while allowing them to track their academic progress more clearly. These results are consistent with Raju et al. (2021) and Umasangadji et al. (2025), who emphasized that badges and progression systems are among the most effective gamification components due to their ability to provide tangible indicators of achievement and motivate continued learning. In terms of learning outcomes, 80% of students reported that gamified challenges improved their programming problem-solving skills, while 72% expressed satisfaction with the ease of use of the learning platform. These findings indicate that the impact of gamification extends beyond engagement to include improvements in knowledge acquisition and skill development. This aligns with Raju et al. (2021), who found that gamification enhances understanding and academic performance through interactive and engaging learning environments. It also supports Umasangadji et al. (2025), who reported that gamification promotes deeper cognitive processing and improves long-term knowledge retention compared to traditional learning approaches. The descriptive statistics further support these findings, with the Engagement and Interaction dimension achieving the highest mean score (M = 4.35), followed by Motivation and Interest (M = 4.20), Gamification Elements (M = 4.12), and Learning Outcomes (M = 4.08). These consistently high values indicate a strong positive attitude among students toward the use of gamification in remote Computer Science education and are consistent with prior literature emphasizing its effectiveness in improving motivation, engagement, and learning performance. Finally, the Chi-Square test results confirmed statistically significant differences at the significance level ($\alpha \leq 0.05$) for all questionnaire items. This demonstrates that participants' attitudes toward gamification were not random but reflected a consistent and meaningful positive perception of its effectiveness. These findings strongly support previous studies suggesting that the systematic implementation of gamification strategies in e-learning environments significantly enhances the overall learning experience and improves educational effectiveness.

5. Conclusion

In light of the findings of this study, the following conclusions can be drawn:

1. The study demonstrated that the integration of gamification elements in remote Computer Science learning environments is an effective instructional strategy that enhances students'

motivation toward learning and increases their interest in educational content. This improvement is reflected in higher levels of engagement and active participation in the learning process.

2. The results revealed that gamification plays a central role in increasing students' participation and interaction with learning activities. It contributes to fostering a sense of immersion and concentration during learning while reducing feelings of isolation, which is one of the major challenges associated with remote education.
3. The study showed that gamification elements vary in their level of impact on learners, with avatars and badges emerging as the most influential components in enhancing students' sense of autonomy, achievement, and self-motivation.
4. The findings confirmed that gamified challenges and learning activities contribute to the development of programming problem-solving skills and the improvement of students' academic performance. This indicates that the impact of gamification extends beyond motivational and affective aspects to include cognitive and skill-based learning outcomes.
5. The relatively high mean scores across all study dimensions reflect a generally positive attitude among participants toward the use of gamification in remote Computer Science education, indicating strong acceptance and recognition of its educational benefits.
6. The results of the Chi-Square test showed statistically significant differences for all questionnaire items at the adopted significance level, confirming that the observed positive effects of gamification are statistically significant and reflect a genuine perception among participants regarding its importance in supporting the learning process.
7. The study further concludes that integrating gamification elements into e-learning platforms can enhance the overall quality of the educational process and improve the effectiveness of digital learning environments, aligning with the requirements of digital transformation in higher education institutions.

6. Recommendations:

Based on the findings of the study, the following recommendations are proposed:

1. Gamification elements should be systematically integrated into online Computer Science curricula due to their significant role in enhancing student motivation, participation, and learning outcomes.
2. Greater emphasis should be placed on the most effective gamification elements, such as badges, reward systems, and avatars, while designing challenge-based learning activities aimed at developing students' programming problem-solving skills.
3. E-learning platforms should be further developed, and faculty members should be trained in the application of gamification strategies based on sound pedagogical principles to ensure the effective achievement of learning objectives.
4. Higher education institutions are encouraged to adopt gamification within their digital transformation and e-learning development strategies, as it contributes to improving the overall quality and effectiveness of educational processes.
5. Future research should further investigate the effectiveness of gamification by examining the impact of individual gamification elements, comparing its application across different disciplines and learning environments, and exploring its long-term effects on academic achievement and skill development.

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