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Research article

Effects of a gamified learning environment on students' achievement, motivations, and satisfaction

Elham Alsadoon [a,*], Amirah Alkhawajah [b], Ashwag Bin Suhaim [a]

[a] Curriculum and Instruction Department, College of Education, King Saud University, Riyadh, Saudi Arabia
[b] Instructional Technology Department, College of Education, King Saud University, Riyadh, Saudi Arabia

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ABSTRACT

This paper aims to investigate the effects of a gamified e-learning environment on computer science learning for middle school students. An e-learning gamification environment was developed and implemented in 8th grade to examine its effects on improving learners' achievement, motivation, and satisfaction to learn computer science online. The study was conducted during the COVID-19 pandemic, where physical distancing was required, which made the conditions very suitable for achieving the goal of this study because teaching was conducted online through an e-learning platform. The effects of the online learning gamification environment were analyzed and interpreted. The pre-test–post-test control group design of the quasi-experiment was used. One hundred thirty-three students in 8th grade were involved in the study. Results indicated that the e-learning gamification environment increased students' motivation to learn computer science ($\alpha < 0.05$) and their satisfaction with the online course ($\alpha < 0.05$) but had no significant effect on their achievement. The study included several recommendations and suggestions for further studies.

1. Introduction

Gamification is a relatively new learning strategy that is being increasingly used in education because of its potential to increase learners' motivation and improve their achievements (Yildirim, 2017; Zainuddin et al., 2020). It supports teaching and learning interestingly and enjoyably through the incorporation of game elements, such as points, levels, badges, and leaderboards. When a gamified class is well-designed, the learners undergo a playful experience that is reinforced with learning opportunities and unprompted feedback that helps them seamlessly improve their knowledge (Bouchrika et al., 2019). The view is that the whole learning experience is improved when using gamification, which has been found to stimulate and improve learners' engagement, motivation, social influence, and academic performance (Zainuddin et al., 2020).

Motivation is a critical element for the success of the teaching-learning process and is linked directly to learning (Gopalan et al., 2017). It stimulates the learners' interest in the academic topic and encourages them to participate enthusiastically in the learning activities, which in turn increases their willingness to learn. The use of different teaching methods and strategies contributes to the increase in learners' motivation toward learning. Several factors in gamification support motivation, such as challenge, control, collaboration, and competition, which makes it a promising approach to making positive changes in students' learning.

Students' satisfaction is another important factor that needs to be studied in gamified learning environments. In general, satisfaction can be viewed as the feeling of happiness that is acquired when a person fulfills his or her needs or desires (Saif, 2014). More specifically, students' satisfaction can be defined as "a short-term attitude resulting from an evaluation of students' educational experience, services, and facilities" (Weerasinghe and Fernando, 2017, p. 533). Students' satisfaction with their learning experiences is an important learning outcome. Students who had positive experiences at school and were satisfied with their learning experience reported higher levels of mental and physical health (Huebner Gilman et al., 2009), high level of academic success (Martirosyan et al., 2014), and overall satisfaction with life and well-being (Suldo et al., 2014).

However, a gap still exists in prior gamification research, because most studies addressed gamification in higher education (Zainuddin et al., 2020), and only a few addressed gamification in online environments (Huang et al., 2019; Sailer et al., 2017). The previous studies were

* Corresponding author.
E-mail address: ealsadoon@ksu.edu.sa (E. Alsadoon).

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also descriptive; hence, this study conducts a quasi-experimental investigation in an attempt to offer evidence of the effects of gamification on improving students' performance, motivation, and satisfaction in the course of Computer Science in the middle school context. The authors investigated gamification quasi-experimentally at the school level and in an online learning setting to explore the extent to which it could affect learners' achievement, motivation, and satisfaction. Moreover, unlike previous research, this study offers an integrated account of achievement, motivation, and satisfaction using three instruments, namely, achievement test, motivation survey, and satisfaction test.

The purpose of this study is to investigate whether a gamified e-learning environment affects middle school students' achievement, motivation, and satisfaction. The study is expected to offer researchers and practitioners empirical data on the effectiveness of the gamified e-learning environment in developing students' achievement, motivation, and satisfaction. That is, the study aims to show the specific effects of gamification design elements on achievement, motivation, and satisfaction. Though the purpose of the study is a pedagogical one, it aims to contribute to the literature on gamification in a learning environment. To achieve the goal of this study, only specific selected elements integrated within the Saudi National Online e-Learning Platform were used to examine their effect on middle school students' learning, motivation, and satisfaction. These three variables were selected because of their relationship with other important factors that affect the target group.

Middle school age is perhaps one of the most difficult times in students' life. At this stage, students undergo several physical and psychological changes. Homework becomes more intense, and school requires spending longer study hours. Thus, it is important to develop interesting learning environments in which the learning experience can capture students' attention and interest. Parra-González et al. (2021) found that active gamification is more valuable as a methodology in Secondary Education than in other stages of education. This research provides insights into the effectiveness of a new strategy in the e-learning environment as an attempt to increase young students' motivation to learn. More specifically, this research will benefit computer science teachers looking for strategies to increase middle school students' motivation, satisfaction, and achievement, giving them insights on whether this strategy could be useful for them.

2. Literature review

2.1. Gamification

Gamification has gained its own space in the educational context because it is believed to improve motivation and learning through the use of game elements. The literature suggests that a noticeable trend to adopt gamification in education as an effective strategy to build highly engaging learning experiences has been observed (Zainuddin et al., 2020). Studies found that using game elements in education makes learning more attractive and increases learners' interaction in the gamified course (Baydas and Cicek, 2019). Gamification is also believed to have a positive effect on learners' motivation, engagement, performance, and learning experience (Zainuddin et al., 2020).

A specific set of gamification elements have been used in this study because they are easy to activate and deactivate in the experimental environment, and are easily visible to the users (Sailer et al., 2017). Thus, the game elements employed in this study include points, badges, levels, and leaderboards. Points are a digital representation of game progress and are used as a reward for provoking specific behaviors. It is used as a reward for success or to recognize different types of effort (Doney, 2019). They encourage students to focus on the task to gain additional benefits (Aldemir et al., 2018). The motivation to use points is to deliver feedback (Sailer et al., 2017).

Badges are visual representations of accomplishment used to serve a particular function in a gamified course (Huang et al., 2019). They can be used as means of providing feedback to the users on how well their performance is (Rigby and Ryan, 2011), or to guide the users by providing them with an idea of what is expected of them (Hamari and Eranti, 2011). In this case, the learners are provided with information on what types of badges they can collect, and it becomes their goal to earn them (Werbach and Hunter, 2012). Therefore, it is important to match the badges used to the objectives of a course (Huang et al., 2019).

Levels refer to the different phases that a player selects to achieve a goal (Huang et al., 2019). They can be used to serve as an indicator of the player's progress from one level to the next, and to represent his or her status because a player who reaches a high level can rationally be considered more advanced than a player who cannot (Duggan and Shoup, 2013). Levels appeal to a player's sense of competence and autonomy and they may be more motivated when they have the freedom to select the level (Huang et al., 2019).

A leaderboard is "a game design element consisting of a visual display that ranks players according to their accomplishment" (Christy and Fox, 2014, p.67). Leaderboards can be categorized into two types based on their design: absolute and relative (Ortiz-Rojas et al., 2019). An absolute leaderboard shows all players with their scores, while a relative leaderboard only shows the rank of the player in comparison to the other players without showing information on the other players. Depending on the type of leaderboard used, studies show a positive effect on task execution punctuality or task performance (Ortiz-Rojas et al., 2019). Evidence has shown that leaderboards provoke competition which in turn creates social pressure to increase engagement in an activity (Burguillo, 2010).

In general, gamification strategy uses elements that stimulate internal and external motivation. Those elements include but are not limited to badges, avatars, points, leaderboards, trophies, and virtual gifts (Zainuddin et al., 2020). For example, the use of the leaderboard stimulates the learner externally, while challenges motivate the learner internally. In addition, cognitive, social, and emotional aspects of the learner are affected by gamification during the learning process. When learners get immediate feedback or face challenges, their cognitive side is affected, whereas when they get recognition for their achievements through badges and points, their emotional side is affected. Meanwhile, when they work cooperatively or their achievements are socially displayed via the leaderboard, their social aspect is affected (Rojas-López et al., 2019). Badges and leaderboards motivate learners, while points encourage learners to accept more challenging tasks (Huang & Hew, 2015). In general, using gamification elements fosters students' extrinsic motivation and their intrinsic value for learning.

2.2. e-learning in Saudi Arabia

The rapid and increasing development of information technology and the Internet has led to qualitative leaps in many sectors, including the education sector worldwide. Saudi Arabia has not been left behind in integrating technologies and harnessing them to improve education. The Ministry of Education in Saudi Arabia sought to encourage the adoption of information and communication technology in education in both sectors, higher education, and K-12 education, which led to the advancement of e-learning and blended learning as a complementary and alternative system for learning across educational institutions in Saudi Arabia (Aljaber, 2018). Saudi Arabia has also adopted the National Information Technology Plan to provide a range of information and communication technology services to schools and educational institutions, and to train teachers and students on utilizing technology in learning (Al-Asmar and Khan, 2014). This step was followed by a wide campaign in 1999 to cover all schools and link them through a wide network that includes all schools in the country; an e-platform that hosted all national curricula and a digital library that allowed teachers to design their e-lessons were also created (Aljaber, 2018). By 2002, the country had fully functional e-resources and an e-learning platform that carried over 50,000 books and 2,500 training courses (Al-Shehri, 2010).

2.3. e-learning, COVID-19 in Saudi Arabia–challenges and opportunities

Education in Saudi Arabia during the period of the COVID-19 pandemic faced several challenges, with students and teachers from various disciplines facing technical challenges, such as the lack of infrastructure for students, including hardware, software, and broadband connection to the Internet that supports conducting virtual classrooms. In particular, teaching computer science during that period was difficult because of the students' inability to work on programs and applications included in their curricula. For example, some students relied on portable devices or smartphones or used computers with old operating systems that did not support the installation of required software and applications, which prevent them from practicing the use of such software (Alsadoon, 2022). The lack of technical skills among students was another barrier that hindered them from downloading programs on their devices in a correct manner and deprived them of the opportunity to practice and apply practical skills (Alsadoon, 2022). Hence, the need to improve and support the technical infrastructure related to online education arose, along with the need to increase the technical skills of all concerned parties from students, teachers, administrators, and parents and develop teachers' digital skills in the field of designing lessons in a way that motivates students to learn online and provide them with opportunities for interaction and participation (Alshehri et al., 2020).

Despite these challenges, many opportunities where distance teaching was used during the pandemic provided an opportunity to explore the potential and advantages of online and blended learning. It was an opportunity to shape the perceptions of students and teachers towards it and reduce resistance to its use (Onyema et al., 2020). With regard to teaching the computer remotely, the role of video has emerged because the use of video in education has different advantages, especially with its support for modern trends in education, such as flipped education and online learning (Alsadoon, 2022). The potential of simulation in facilitating learning computer science online for students, because it played an important role as alternatives to the actual practice of programs and applications, should be included in the curricula (Alsadoon, 2022).

2.4. Theoretical background

Several theories have strong implications for the development of a gamified learning environment and are frequently cited in this context (Huang and Hew, 2018), such as self-determination theory (SDT), behavior reinforcement theory, goal-setting theory, social comparison theory, and flow theory. The theory with a significant influence on the gamification framework of this study was SDT.

Self-determination theory (Deci and Ryan, 1985) focuses on intrinsic motivation and identifies three innate psychological needs that lead, if satisfied, to reinforce students' intrinsic motivation: a sense of competence, relatedness, and autonomy. The more these three needs are fulfilled, the higher the levels of learners' intrinsic motivation (Baydas and Cicek, 2019). Studies suggest that using the elements of gamification can fulfill these needs (Aldemir et al., 2018; Baydas and Cicek, 2019; Huang and Hew, 2018; Huang et al., 2019).

Competence refers to the need to be effective and able to overcome the problems in the setting (Baydas and Cicek, 2019). In a gamified system, competence can be induced by the use of badges and leaderboards (Sailer et al., 2017). Relatedness refers to the need to feel a sense of belonging and connectedness with others (Baydas and Cicek, 2019). It can be evoked by providing chances for learners to work together to achieve a shared goal (Sailer et al., 2017). Autonomy refers to the need to be able to control or manage one's own life (Baydas and Cicek, 2019). In a gamified system, autonomy can be met by enabling learners to take direct action by being able to choose from a list of different options (Huang et al., 2019).

Huang et al. (2019) identified five core elements that are associated with motivation and that need to be considered when a learning environment is to be gamified. They linked these elements to the gamification elements as shown in Table 1. These motivation elements are goals, access, feedback, challenge, and collaboration. Goals are rules that help the learner understand how to play and what they need to do. Access is the ability to control the environment. Feedback is the information provided to learners that informs them of their performance. Challenge refers to offering different levels of difficulties. Collaboration refers to working and interacting with other players. According to Doney (2019), it is crucial to set attainable goals, deliver clear rules, choose a level of challenge that is not too hard or too easy, and provide meaningful feedback.

The connection between the five core motivating elements and SDT elements is shown in Table 1. As shown in the table, relatedness and collaboration are connected, autonomy and challenges access/control are connected, and competence and feedback, challenges, access, and goal are connected (Doney, 2019; Huang et al., 2019). Therefore, in gamified systems, autonomy can be achieved by the use of levels, while competence can be achieved by the use of points, badges, levels, and leaderboards.

3. Methods

3.1. Study design

Quasi-experiment was used because the random assignment is difficult to obtain, and it is suitable for the purpose of this study, which is to evaluate the effectiveness of the independent variable (teaching strategy) in the dependent variables (academic achievement, students' motivation, and satisfaction). In other words, Quasi-experiment was used to test the causal consequences (Cook, 2015). The authors selected this approach to control the variables and determine the causality between the variables. In addition, it better controls the confounding variable that influences the cause and effect. Two group-pre-test–post-test design, in which the dependent variables are measured before the treatment is implemented and after it is implemented, was used. "Pre-test-post-test control group designs are well suited to investigating effects of educational innovations and are common in educational research" (Dugard, 1995, P. 181). This design compares the changes that occur within two different groups on variables of achievement, motivation, and satisfaction by measuring the variables at two time periods, before and after the independent variable (i.e., gamified learning**),** which is called the experimental manipulation or intervention. As stated earlier, the design aims to establish causality between gamified learning (independent variable) and achievement, motivation, and satisfaction (dependent variables). In following such a design, the authors could reveal whether gamified learning affects achievement, motivation, and satisfaction.

3.2. Research null hypotheses

1. The e-learning gamification environment does not affect middle school students' achievement in a computer science course.
2. The e-learning gamification environment does not affect middle school students' motivation to learn computer science.
3. The e-learning gamification environment does not affect middle school students' satisfaction with computer science courses.

3.3. Research questions

This study aims to answers empirically the following research questions, each of which reflects the research hypothesis stated previously.

1. To what extent could the e-learning gamification environment in the middle school affect students' achievement in a computer science course?
2. To what extent could the e-learning gamification environment in the middle school affect students' motivation in a computer science course?

Table 1. Core elements associated with motivation linked to the gamification elements.

Gamification elements	Core motivation elements (Huang et al. 2019) pedagogical factors (Doney, 2019).	SDT (Deci and Ryan, 1985)	How it was implemented
Points Badges	Goal	Competence	A clear goal for each lesson was set and presented at the beginning of the unit. Students were asked to accomplish these goals and earn badges.
	Feedback		Feedback with an explanation of the answers instantly appeared to the learners when they were answering the questions in real-time. At the end of the activity, the total grade was displayed to the learner. Collecting the points and badges as a reward for the correct answers was considered part of the instant feedback. Students collected one point for each learning activity completed and earned a badge when 5 points were collected.
	Collaboration	Relatedness	To promote collaboration and communication (a sense of relatedness), some activities were designed as a team assignment, which allowed learners to collaborate and interact with each other to achieve shared goals to collect points and badges by providing a space for discussion and sharing their experiences while working on the activities.
Levels	Challenges	Competence	An appropriate challenge with varying levels of difficulty was provided.
	Access (control)	Autonomy	Students were given the freedom to access the activities any time of the day and redo them.
			A learner had the freedom to choose from various levels of activities.
Leaderboard	Feedback	Competence	A leaderboard can foster participants' sense of competence and challenge them to place themselves near the top of the leaderboard, which also works as feedback on their performance.
	Challenges		It is arranged automatically by the system according to students' points.

3. To what extent could the e-learning gamification environment in the middle school affect students' satisfaction in a computer science course?
4. Are there differences between the means of the test scores of achievements, motivation, and satisfaction of the experiment and control group? If yes, are they significant?

3.4. Learning setting

The experiments were conducted during the Fall of 2020. Because of the COVID-19 pandemic, the course was delivered online. The Saudi National Online e-Learning Platform was used to deliver online learning for both groups over a 15-week semester. Gamification elements were applied to the experimental group. The course unit that was selected to be taught pertained to computer networks, the Internet, information security, society knowledge, and developing design presentation skills. In the first week, the experimental group was oriented to help students understand the criteria for collecting points and badges. The procedures followed by the researchers are explained in Table 1. To control the effect of the instructor, all groups were taught by one instructor. Learning materials and activities were distributed to both groups through the e-learning platform.

The Institutional Review Board (IRB) was obtained from the Human Research Ethics Committee at the Deanship of Scientific Research at King Saud University. The committee is responsible for reviewing all research projects before their initiation (whether funded or not) involving human participants, and is concerned with protecting the welfare, rights, and privacy of human subjects. The authors adhere to the ethical standards set by the research committee. The Human Research Ethics Committee approved the conduct of the study at King Saud University. A letter was sent to the parents to collect their consent. Students' academic achievement and motivation to learn computer science were assessed through pre-measurement for both groups during class time. The same measurement was given to the students at the end of the semester. In addition, a students satisfaction survey was given to the students at the end of the semester. All measurement tools were administered online. The motivation and satisfaction questionnaires were filled in individually and anonymously. Students were provided with the objectives of the study, and they were informed that the completion of the questionnaire was voluntary and that it was not intended to evaluate them. Compensation was given to a randomly selected participant in each class (a total of four). By announcing the compensation, which was a 25$ prepaid gift card, the response rate was 100%.

3.5. Designing the gamified learning environment

The main goal of the study was to examine the effects of a gamified learning environment on students' achievement, motivation, and satisfaction. Therefore, when designing the gamified learning environment, the researchers followed SDT (Deci and Ryan, 1985), which aims to fulfill the following needs: competence, relatedness, and autonomy, considering the core motivation elements: goal, access, feedback, challenges, and collaboration (Huang et al., 2019), and focused on some pedagogical factors that make gamification effective, such as challenges, feedback, competition, control, interaction, and goals (Doney, 2019). Four elements of the gamification, namely, points, badges, levels, and leaderboard, were implemented. Table 1 explains how these elements were implemented and how they were linked to the motivation elements and the elements of SDT.

3.6. Participants

A convenience sample, which involves respondents who are convenient to the researchers, was used. A school in Riyadh in Saudi Arabia was selected because it was close at hand and easy to work with. It was a middle school that teaches using the Arabic language and follows the Arabic curriculum. A sample of 8th-grade students participated in the study, and it included four classes. Two classes were assigned randomly as the control group while the other two were assigned as the experimental group. A total of 133 students with ages ranging from 13 to 14 years participated in the study (67 in the experimental group and 66 in the control group). Using G*Power software, the sample size needed with power = 0.95 and effect size = .25 was 74. Thus, the sample of 133 satisfied the required sample size for the MANOVA test.

3.7. Measures and metrics

Data were gathered using three instruments:

The achievement test was written by two qualified teachers. It consisted of twenty multiple-choice items, with ten true and false items with a total

score of 50. The pre-test aimed to ensure the equivalent of the two groups in their prior knowledge of the learning materials, while the post-test aimed to assess their achievements in comprehending the materials.

Motivation toward Learning developed by Tuan et al. (2005) was used. It was developed to measure students' motivation to learn science. The survey was taken from Lin Tuan et al. (2005), was validated by the authors, and was designed to measure students' motivation toward science learning. The survey consists of six sections (1. self-efficacy, 2. active learning strategies, 3. science learning value, 4. performance goal, 5. achievement goal, and 6. learning environment stimulation. The survey has 35 statements distributed as follows: seven statements in the first section, eight statements in the second section, five in the third section, four in the fourth section, five in the fifth section, and six in the sixth section. The survey adopted a five-point Likert scale, which is validated by the authors. The advantage of adopting a five-point Likert scale lie is that it allows for a lower margin of error, meaning any scale without a neutral option can distort results. It also ensures the accuracy of results by giving respondents an option to be neutral rather than imposing them to choose an alternative that does not reflect their opinion (Lionello et al., 2021). The scale has high reliability with a Cronbach's alpha of 0.93. In this study, the scale was adopted to measure motivation to learn computer science. Thus, the word *science* in the original statements was substituted by the word *computer science*.

Students' satisfaction. To compare students' satisfaction with the learning experience in both groups, three questions about satisfaction were added to the survey. They were measured using a five-point Likert scale.

3.8. Analyses of the data

The reliability of the scales was examined using Cronbach's alpha coefficient (Table 2). A pre-test was conducted to compare the students' prior knowledge of the course content and their motivation to learn it. The results of the pre-test data showed that the normality of data was not violated. Therefore, parametric tests were used in subsequent analyses.

Inferential statistical analysis was used. Computation of the one-way MANOVA procedure was conducted using Statistical Package for Social Science (SPSS 18.0) and included the analysis of the data collected from the pre-test and post-test, the questionnaire grades of learning motivation, and satisfaction. The two levels of learning strategy (gamification and conventional teaching) were the independent variables, while the dependent variables were learning achievement, learning motivation, and satisfaction. As suggested in the literature, the alpha was established a priori at the 0.05 level (Lionello et al., 2021).

4. Results

This study was conducted to investigate the effectiveness of gamification in middle school students' achievement in computer science, their motivation to learn, and their satisfaction with the course. MANOVA test results were used to determine whether a significant difference between the group that learned within an e-learning gamified environment and the control group existed in terms of their academic achievements, motivation, and satisfaction. At the beginning of the course, no significant difference between the control and the treatment groups was observed in terms of prior knowledge and motivation to learn the subject as indicated by the MANOVA test result) $F = 0.766$, $P = 0.469$, Wilks, Lambda $= 0.977$, partial eta squared $= 0.023$, $\alpha > 0{,}05$).

Levene's test of equality of error variances was conducted to test the assumption of MANOVA and ANOVA that the variances of each variable are equal across the groups. Correlation among dependent variables was tested and no correlation was found among them. The assumption of homogeneity of covariance between the groups was checked by Box's test. Box's M (8.094) was not significant, p (.246) > (.005)—indicating the absence of significant differences between the covariance matrices. Therefore, the assumption was not violated and Wilk's Lambda is an appropriate test to use.

At the end of semester, using an alpha level of .05, the MANOVA test was significant, Wilk's $\Lambda = .860$ $F(3, 129) = 7.014^{b} < .005$, multivariate $\eta^2 = .14$. This significant F indicates that significant differences between the groups could be observed on a linear combination of the dependent variables. The multivariate $\eta^2 = .14$ indicates that approximately 14% of the multivariate variance of the dependent variables is associated with the independent variable. Table 3 present the results of MANOVA.

Because the MANOVA was significant, univariate ANOVA results were examined. A post hoc multiple comparison was conducted. Table 4 present the results of Post Hoc test. Results showed significant differences between the two groups in their motivation to learn computer science and their satisfaction with the course because of the teaching methods. Using the G*power software, the effect size $= 0.13$. Cohen suggested that $d = 0.2$ be considered a "small" effect size.

Data analysis revealed the absence of statistically significant differences in the mean scores of the achievement test between the experimental and control groups ($F = 0.22$, partial eta squared $= 0.002$, $\alpha >$ 0,05). This result is consistent with the results of several previous studies that showed the ineffectiveness of gamification in developing computer academic achievement, or developing computer skills for university and higher education students (Gafni et al., 2018 Pilkington, 2018; Mese and Dursun, 2019). This result is also consistent with the results of several previous studies that concluded that the use of gamification did not show a positive effect on academic achievement in various courses, such as science, mathematics, and English among middle and high school students (Prasetyo and Napitupulu, 2018; Khan et al., 2017).

Results also showed a statistically significant difference between the experimental and control groups in the motivation test in favor of the experimental group ($F = 9.5$, partial eta squared $= 0.068$, $\alpha < 0.05$). Similarly, a statistically significant difference between the experimental and control groups in the satisfaction test in favor of the experimental group $F = 10.3$, partial eta squared $= 0.074$, $\alpha < 0.05$) was observed. This result is consistent with the results of previous studies that showed the effectiveness of using gamification in developing motivation for learning in the field of computers (Gafni et al., 2018; Pilkington, 2018; Rojas-López et al., 2019). This result is also consistent with previous studies that found the effectiveness of using gamification in developing motivation towards learning for various courses such as science physics (Aşıksoy, 2017; Hursen and Bas, 2019).

5. Discussion

This study aimed to examine whether the e-learning gamified environment influenced the achievement, motivation, and satisfaction of 8th-grade students in a computer science course. Multivariate analysis was applied to detect significant differences between the groups because of the use of gamification. The findings revealed acceptance of the first null hypothesis, meaning no effect of gamification on achievement was observed, and rejection of the second and the third null hypotheses, which demonstrated a significant effect of gamification on motivation and satisfaction. Thus, the research questions were answered because the research questions were formulated according to the research hypotheses. Specifically, the answer to the first question showed the absence of the effect of gamification on students' achievement while the answers to the second and third questions indicated the effectiveness of gamification in the students' motivation and satisfaction. The ensuing lines are the discussion of the main findings of the study.

The results did not show that gamification affected students' achievement. Meanwhile, results showed that using gamification

Table 2. Cronbach alpha coefficients of the instrument.

	Number of Items	Cronbach Alpha
Satisfaction	3	.901
Motivation	28	.916

Table 3. MANOVA results.

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.994	7082.364[b]	3.000	129.000	.000	.994
	Wilks' Lambda	.006	7082.364[b]	3.000	129.000	.000	.994
	Hotelling's Trace	164.706	7082.364[b]	3.000	129.000	.000	.994
	Roy's Largest Root	164.706	7082.364[b]	3.000	129.000	.000	.994
class	Pillai's Trace	.140	7.014[b]	3.000	129.000	.000	.140
	Wilks' Lambda	.860	7.014[b]	3.000	129.000	.000	.140
	Hotelling's Trace	.163	7.014[b]	3.000	129.000	.000	.140
	Roy's Largest Root	.163	7.014[b]	3.000	129.000	.000	.140

Table 4. Post Hoc test.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Satisfaction	8.282[a]	1	8.282	10.430	.002	.074
	Motivation	2.243[b]	1	2.243	9.568	.002	.068
	Achievement	8.036[c]	1	8.036	.222	.638	.002
Intercept	Satisfaction	2334.658	1	2334.658	2940.240	.000	.957
	Motivation	2179.432	1	2179.432	9296.104	.000	.986
	Achievement	272989.931	1	272989.931	7534.605	.000	.983
Class	Satisfaction	8.282	1	8.282	10.430	.002	.074
	Motivation	2.243	1	2.243	9.568	.002	.068
	Achievement	8.036	1	8.036	.222	.638	.002
Error	Satisfaction	104.019	131	.794			
	Motivation	30.712	131	.234			
	Achievement	4746.325	131	36.231			
Total	Satisfaction	2445.000	133				
	Motivation	2213.563	133				
	Achievement	277782.000	133				
Corrected Total	Satisfaction	112.301	132				
	Motivation	32.956	132				
	Achievement	4754.361	132				

affected the students' motivation to learn computer science and their satisfaction with the course. This result confirms previous studies (Gafni et al., 2018; Pilkington, 2018) that showed that using gamification did not affect students' achievement in the computer science field though it affected their motivation towards learning. Both groups had equivalent e-learning environments in which their teacher provided the same content, learning activities, and feedback. Both groups did not differ in their achievement, which could be because of the similar level of intrinsic motivation to learn the subject (Gafni et al., 2018). The results of this study differ from Jurgelaitis et al. (2018), who showed a positive effect of gamification on students' grades in the design of information systems for students of computer science. The reason for this difference may be due to the educational level covered by the study, which was undergraduate students. Moreover, in the current study, students' grades in both groups were high, which could be another reason why no significant difference was detected in achievement. In other words, choosing a more challenging unit could reveal the real difference between the two groups in terms of achievement. Another explanation might be that the achievement test was applied remotely during the remote emergency teaching period due to COVID-19, and thus, the tests were not properly proctored. It could have given some students chances for obtaining external assistance, such as referring to the book or other sources or having discussions with their peers regarding the test.

However, the results agree with other studies that found a positive effect of gamification on students' motivation (Bouchrika et al., 2019; Doney, 2019). This positive effect can be explained by the use of an e-learning environment which might have attracted students' attention and encouraged them to participate in learning activities. Students in the gamification group learned enjoyably by competing with themselves and with others to receive the awards, namely, points and badges, which reflected their motivation to learn and their satisfaction with the course. They enjoyed having the freedom to select levels. The feedback they received guided them to learn, which in turn influenced their extrinsic motivation. Moreover, the results can be related to the fulfillment of students' innate psychological needs of SDL, a sense of competence, relatedness, and autonomy. This result is in agreement with Parra--González et al. (2021) who showed that gamification improved students' capability of developing autonomy and collaboration.

It is worth mentioning that the use of gamification also had an indirect effect. The teacher observed that the students got involved and interacted with their peers and used e-learning technologies more in the gamification group. This effect was also noticed by a previous study (Bouchrika et al., 2019). These indirect outcomes of using gamification are essential needs for students at this age. The significant difference between the two groups in their motivation to learn and their satisfaction with the course are added value to the use of gamification strategy in K-12 education. Hence, the gamification strategy increases students' motivation at the middle school level and their satisfaction with the course. These are two important factors among the targeted outcomes to be achieved because they go hand in hand with achievement.

5.1. Limitations

Some aspects of the study design limit the external generalizability of the study findings. The current study focused on a convenient sample of 8th-grade female students. Moreover, the achievement test was applied

remotely during the remote emergency teaching period due to the COVID-19 pandemic, which could have affected the accuracy of the results. These limitations can be accounted for in future studies.

6. Conclusion

In this study, the researchers investigated whether gamification could reinforce students' learning outcomes, such as achievement, motivation, and satisfaction. The study confirmed that the gamification strategy has a positive effect on students' motivation and satisfaction, which is an important desirable outcome because of the strong influence of these two elements on students' learning. However, the results of this study did not have any effect on students' achievement. The e-learning environment of this study was developed through the Saudi National Online e-Learning platform, which is relatively new. This platform supports only a few elements of gamification that were used in this study. The findings of this study support the incorporation of more gamification elements in e-learning platforms. Although the use of the gamification elements in this study did not have any effect on students' achievements, the effect it had on their motivation and satisfaction is a desirable outcome, especially for middle school students. found that middle school students' satisfaction contributes to better attendance and better grades.

This study has several strengths. It used theory to guide the design of a gamified learning environment. Hence, it is recommended that when designing gamification, it should be done according to the rules and principles of designing gamification in education because it can affect the development of the motivation towards learning. It is also recommended that studies that follow a mixed approach should be conducted to understand the role of each element of gamification in developing motivation toward learning. The research also contributed to increasing knowledge on the positive effects of gamification on students' motivation and satisfaction at middle school age.

Future research should use a better-controlled testing environment in which a proctoring tool is used during the achievement tests to obtain more accurate results in terms of achievement. It is also recommended that the experiment be conducted in a blended learning environment in which students have in-class exams. Researchers may also consider collecting qualitative data through students' interviews to gain deeper insights into why they were or were not motivated in the gamified learning environment. Further, a rigorous investigation of the effect of gamification on learners' performance, motivation, and satisfaction using an experimental design and a large sample would also be interesting to conduct. Longitudinal studies on gamification are necessary to trace the development of the students over time.

Declarations

Author contribution statement

Elham A Alsadoon: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Amirah Alkhawajah: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper. Ashwag Bin Suhaim: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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