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The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system

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ABSTRACT

This study investigated the differences in learners' performance and perceived engagement between three intervention groups in a Science class, using two types of pedagogical intervention: traditional instruction with paper-based quizzes and gamified instruction with gamified e-quizzes as formative assessments. With respect to the gamified instruction, three types of gamification applications were employed: Socrative, Quizizz, and iSpring Learn LMS. The effects of the instructional intervention ($n = 94$), as well as evaluative feedback, were obtained with the aid of formative quizzes, post-questionnaire surveys, and personal interviews. The results showed that the employment of innovative gamified e-quiz applications (i.e., Socrative, Quizizz, and iSpring Learn LMS) and paper-based quizzes were effective in evaluating students' learning performance, particularly as formative assessment after completing each topic. Finding ways to apply games or game concepts in the classroom can be a promising and innovative tool for educators to engage their students in creative learning skills and attractive competition.

1. Introduction

Gamification is a growing trend in education due to its influence on student learning (Göksün & Gürsoy, 2019). Gamification is an educational approach to facilitating learning, encouraging motivation and engagement, improving learner participation and lesson interactivity, and stimulating learners such that it leads to an expansion of their knowledge (Göksün & Gürsoy, 2019; Lopez & Tucker, 2019; McGonigal, 2011). Its proper implementation can increase intrinsic motivation and engagement, and it is a powerful tool for teachers at all levels within the educational system (Jurgelaitis, Čeponienė; Čeponis, & Drungilas, 2019; Kuo & Chuang, 2016). The interest of researchers in gamification with regards to education is growing (e.g., Ge, 2018; Göksün & Gürsoy, 2019; Huang & Hew, 2018; Kyewski & Kramer, 2018; Tsay, Kofinas, & Luo, 2018). Several studies have explored how gamification can positively influence student learning (Groening & Binnewies, 2019; Lopez & Tucker, 2019).

Lack of motivation and engagement is a particular problem for students taking courses in universities or schools (Adukaite, van Zyl, Er, & Cantoni, 2017). According to the findings of many studies (Bouwmeester et al., 2019; Lo & Hew, 2018), traditional strategies cannot provide a solution to the absence of student motivation. Likewise, they cannot bring about engagement in learning (Ortiz-Rojas, Chiluiza, & Valcke, 2019; Sousa-Vieira, López-Ardao, Fernández-Veiga, Rodríguez-Pérez, & Herrería-Alonso, 2016). Hence, it has been suggested that gamification should be introduced to the educational system as an effectual means of improving learner motivation and

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engagement.

An advantage of gamification is that it makes learning fun through friendly competitions, challenges, and rewards, making it an excellent means of encouraging students' engagement in learning (Hamari et al., 2016). It helps a learner to develop critical thinking and multi-tasking skills (Ding, Er, & Orey, 2018). Moreover, gamification provides a source of data as regards student learning, thereby ensuring more effectual, precise, and timely information for teachers, parents, administrators and public policymakers (Zainuddin, 2018).

Gamification involves the use of features like scores, badges, rankings, and rewards, making immediate feedback possible. This encourages students to engage in the learning environment and enables them to accomplish tasks. During gamification, it is possible to monitor and assess successful learning (Hassan, Habiba, Majeed, & Shoaib, 2019) and provide feedback on the assessment to students for formative purposes. The use of gamification as a formative assessment tool allows the teacher to obtain initial information concerning individuals' learning processes (Göksün & Gürsoy, 2019). Likewise, the use of gamification for assessment reveals the merits and shortcomings of game design. It is possible for gamification to be an option in assessing students (Huang & Hew, 2018).

However, only a few studies have examined the use of gamification to assess student learning, especially as formative assessment (e.g., Göksün & Gürsoy, 2019; Ismail et al., 2019; Zhang & Fang, 2019). Hence, a knowledge gap exists in the literature as regards the effect of using gamification for assessment. In the study, gamification is used as a formative assessment tool to enhance student learning performance and engagement. The present study aims to determine the impact of the formative assessment conducted with three gamification tools on the learning achievement and engagement of secondary school students in learning science, specifically in relation to natural disaster topics.

Any software or tool that applies game mechanics to non-game environments in order to enhance engagement and overall success is known as a gamification platform. On reviewing previous studies in the literature, we found that the Kahoot application was used more frequently in gamification activities when conducting formative assessment (i.e., Bawa, 2019; Bicen & Kocakoyun, 2018; Guardia, Del Olmo, Roa, & Berlanga, 2019; Göksün & Gürsoy, 2019; Martins, Geraldes, Afonseca, & Gouveia, 2019). However, since these studies only focused on the similar characteristics of gamification platforms (i.e., Kahoot and Quizizz), we regard this issue as a research gap requiring further studies involving the implementation of a gamification application with different assessment features. Therefore, this study attempts to fill this gap by expanding and employing three other gamified platforms – Socrative, Quizizz, and iSpring Learn LMS – which are not identical and have different unique assessment tools. At the same time, this study attempts to determine the strengths and weaknesses of these gamification platforms based on their specific features and evaluation characteristics.

Another gap identified from our review of previous empirical gamification studies is the notion of learner engagement. Reeve and Tseng (2011) proposed four types of learner engagement: emotional, agentic, behavioral and cognitive. Previous studies have not elaborated all four types of engagement in the context of gamification implementation together. Lo and Hew (2018) discussed a single type of engagement (i.e., cognitive engagement), while Huang, Hew, and Lo (2018) reported two types of learner engagement in their study (i.e., behavioral and cognitive). The current study builds on Reeve and Tseng's (2011) typology of learning engagement in a gamified pedagogy classroom context (Fig. 1).

The purpose of this study was to assess the effect of gamified learning on students learning performance and engagement in a formative assessment context. Four types of learning engagement (behavioral, emotional, cognitive and agentic) were conceptualized for assessment. Based on the literature review, the primary research question in this study was: "What are the effects of employing gamification applications as formative assessment platforms on students' learning performance and engagement?" The secondary questions were:

1. Does gamification as a formative assessment platform positively influence students' learning outcomes?

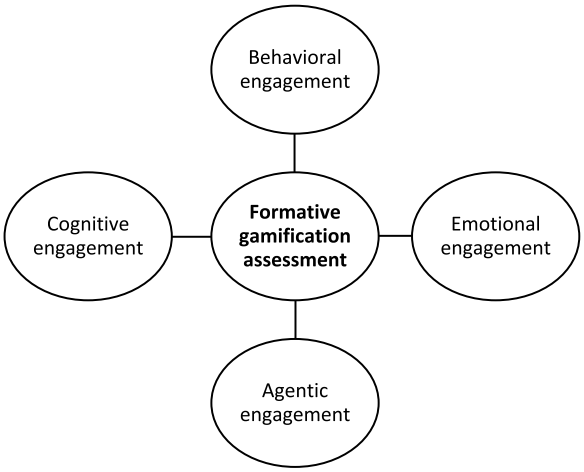

Fig. 1. Reeve and Tseng (2011)'s typology of learning engagement adapted for the current study.

2. Are there any significant differences between paper-based quizzes and gamified e-quizzes in terms of students' learning achievement?
3. To what extent does gamification as a formative assessment platform influence student engagement in learning?
4. What are the students' learning experiences and perceptions of involvement in gamified learning activities using the three different platforms (Socrative, Quizizz, and iSpring Learn LMS)?

2. Method

A mixed-method design was employed in this study whereby quantitative information (i.e., formative assessment quizzes and questionnaires) gathered in the first stage was subsequently supported by qualitative data (interviews) in the second stage. Such triangulation of quantitative and qualitative data within a single study enables the researcher to interpret the findings from different angles (Creswell & Creswell, 2017). This method is in line with previous research on gamification using mixed methods (e.g., Baydas & Cicek, 2019, pp. 1–17; Chang & Wei, 2016; Ding at al., 2018; Lo & Hew, 2018).

The independent variable in this study was the pedagogical intervention type: traditional instruction with paper-based quizzes and gamified instruction with gamified e-quizzes. Concerning the gamified instruction, three types of gamification applications were employed (i.e., Socrative, Quizizz, and iSpring Learn LMS). One of the dependent variables examined was students' learning achievement, which was measured by paper-based quizzes and gamified e-quizzes (online gamification quizzes). These quizzes were conducted during the intervention period as formative assessments. The other dependent variable was student engagement in learning.

2.1. Participants

Participants in the intervention study were non-randomly selected from three different classes to form three groups. This is in accordance with Creswell and Creswell (2017), who stated that a non-randomization design is one of the features of quasi-experimental research targeted at preserving a natural setting. Ninety-four Indonesian secondary school students from three different science classes took part in the study. The students were aged between the ages of 15 and 16 years and were asked to fill out the survey questionnaires pertaining to their perceived level of learning engagement and to participate in the treatment and assessment. Regarding the interview session, six students were invited from each group to be interviewed on their learning experiences and perceived engagement in gamified learning instruction and gamified e-quizzes.

2.2. Settings

The three groups of participants received both conventional and gamified instruction. The same instructor taught the three groups

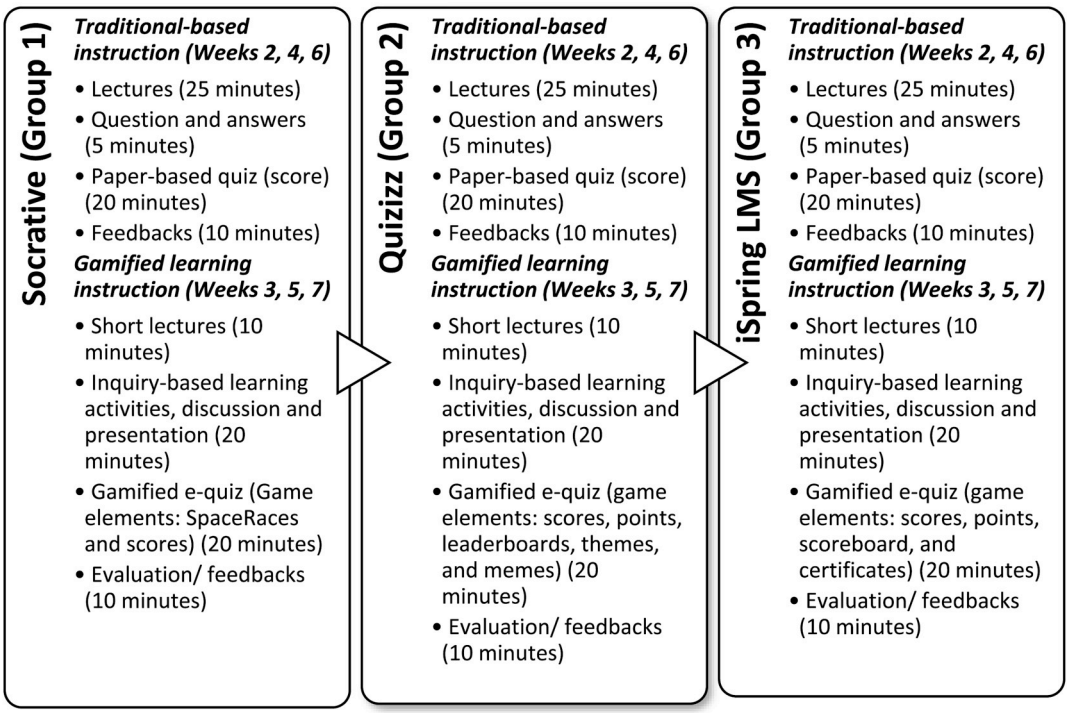

Fig. 2. Course design of the three intervention groups.

with the same content once a week, with each meeting lasting 60 min. From a course design perspective, a summary of the instructional intervention outline for the three groups is given in Fig. 2. In terms of conventional instruction, the three groups engaged in similar in-class activities, starting with conventional instruction in the first meeting, followed by question-and-answer (Q&A) sessions, a paper-based quiz, and feedback. Furthermore, the three groups also received gamified instruction in the class the following week with the same content taught or a continuation of the previous incomplete lesson.

During the gamified learning activity, the class began with a short lecture, which was followed by inquiry-based learning activities, discussion and presentation, a gamified e-quiz, and evaluation/feedback. The gamification quiz platform employed for Group 1 was Socrative (https://www.socrative.com/); for group 2, Quizizz (https://quizizz.com/); and for group 3, iSpring Learn LMS (http://www.ispringsolutions.com/learn-lms). These three gamified platforms were chosen because of their easy and adjustable e-quiz design. Based on the content taught in the class, similar quiz questions were given to the three intervention groups through the different platforms after each lecture.

2.3. Gamified platforms

The Socrative, Quizizz, and iSpring Learn LMS platforms were selected due to the easy design of their quiz questions as well as the fact that they can be played separately and simultaneously.

2.3.1. Socrative

Socrative is an online assessment tool that enables instructors not only to provide in-class quizzes to students, but also to visualize and monitor student learning, create reports, and view students' responses in real-time without any fee or charge. A creative assessment tool makes learning and progress easy to assess by learners and teachers. It also enables teachers to create short-answer,

Fig. 3. A quiz question and leaderboard on the Quizizz platform.

multiple-choice or true/false question quizzes that can be saved and used repeatedly. The teacher introduces the quiz in a class, and the students provide answers to the quiz on their device in real-time. Although it does not have Player Leaderboard like iSpring Learn LMS and Quizizz, it has a "SpaceRace" game in which a student's rocket is propelled forward by correct answers.

2.3.2. Quizizz

Like Kahoot, Quizizz is a free classroom assessment/review tool that helps in evaluating students' understanding as well as providing them with a fun review. Users can sign-up for a free account on this platform, which allows them to create multiple quiz questions. While creating a quiz, users are required to provide a name for the quiz, give it an image, as well as set it as private or public. Although no passwords or usernames are required, students are given a 6-digit code to access the quiz. Memes, avatars, themes, music, and leaderboards are available on this platform to make learning interesting and engaging. Each question was given a 30-s loading time in this study. Fig. 3 below depicts an example of a quiz question and leaderboard on the Quizizz platform.

2.3.3. iSpring learn LMS

This online gamification platform allows students to compete for an unlimited number of badges and points. The iSpring Quiz Maker (https://www.ispringsolutions.com/ispring-quizmaker) was used by the instructor to design the online quiz questions and was directly linked to Microsoft PowerPoint (PPT). By using the PPT iSpring Quiz Maker, the instructor was able to design a quiz easily and upload it to the iSpring Learn LMS. Pictures, texts, and videos were used in the quiz. Twenty-three question categories such as type in, word bank, matching, fill in the blank, true/false, blank slide, numeric, multiple-choice, and sequence are also contained in the iSpring Quiz Maker. The quiz was uploaded to the iSpring Learn LMS platform (https://www.ispringsolutions.com/ispring-learn) after it had been created on the iSpring Quiz Maker. This LMS allows students not only to answer the e-quiz question and earn badges and points but also to monitor their progress on the leaderboard. At the end of the class, certificates for course completion can also be easily downloaded and printed from the platform. Participants in this survey were awarded 5 points for correctly answering the test question and were also not penalized for any mistake.

2.4. Procedures and data analysis

The research activities, which included preparation, intervention, and assessment activities, were performed within eight weeks, as presented in Fig. 4. In the first week, the students were trained and introduced to each gamified platform as well as the concept of gamification. Intervention or teaching-learning activities were conducted in the second week through the seventh week, whereby lectures were given on three different topics concerning a natural disaster. The learners were given three paper-based quizzes after each lecture or at the end of each class hour as well as three gamified e-quizzes the following week with different questions but on the same topic or lesson. Both types of quizzes were made up of 20 questions, with each correct answer given a score of 5 points, meaning that each test had a total score of 100 points. Landslides and volcanic eruptions were discussed in lesson 1, illegal logging and flooding was the topic of lesson 2, and lesson 3 was about tsunami and earthquakes. The six formative assessments (3 paper-based quizzes and 3 gamified e-quizzes) were aimed at evaluating the learners' understanding of the topics they had been taught. With the aid of questionnaire surveys and personal interviews, the intervention activities were finally evaluated in week eight. The aim in conducting these activities was to obtain data pertaining to the learning experiences and perceived engagement of students receiving gamified instruction.

Ninety-four students from three groups took part in both conventional instructions with paper-based quizzes and gamified learning instruction with gamified e-quizzes. Closed-ended questions were used in the questionnaires as in Reeve and Tseng (2011). The

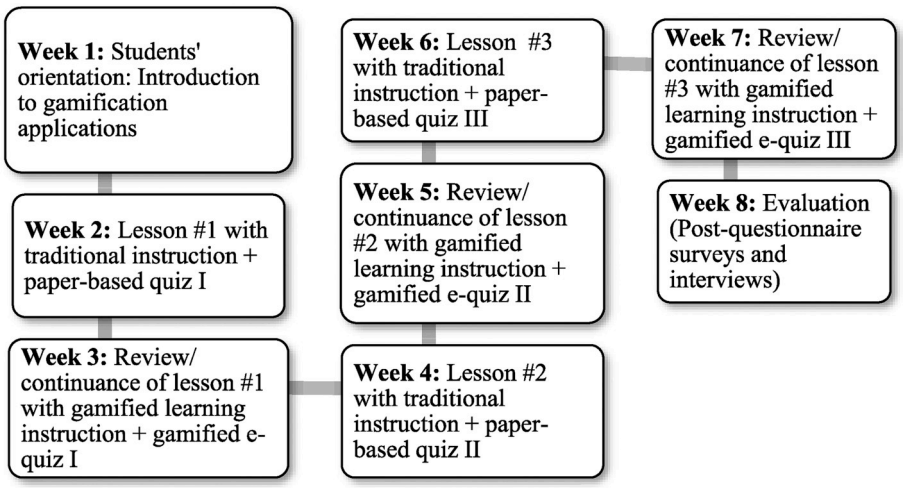

Fig. 4. Data collection and time allocation.

questions were structured in line with a 5-point Likert Scale, ranging from strongly agree to strongly disagree and were categorized into cognitive, behavioral, emotional and agentic engagement (Appendix 1). Interviews conducted with teachers, students and experts in educational technology were used to validate the instrument's content. Cronbach's Alpha coefficient of internal consistency was used to measure the reliability of the instrument and was found to be greater than 0.8, which is an acceptable level of reliability.

It took the participants about 10–15 min to complete the questionnaires, which were presented in a paper-based format. The paper-based questionnaires were distributed to students during the data collection, and all data was then imported as a text file into SPSS for analyses. Since the assumptions of the normal distribution of the data were not satisfied the Kruskal-Wallis Test (Kruskal, 1952), an independent samples nonparametric test, with a significant level of $p < .05$ was employed (instead of ANOVA) to determine whether there were any differences between the three groups, while pairwise comparison was evaluated with a Post-hoc test. This rationale is in line with previous studies in the relevant literature, in which the Kruskal-Wallis test and Post-hoc test were employed in analyzing the quantitative data (e.g., Mavroudi & Tsagari, 2018; Prisacari & Danielson, 2017; Srba, Savic, Bielikova, Ivanovic, & Pautasso, 2019). In addition, the Mann-Whitney *U* test (Mann & Whitney, 1947) ($p < .05$) was also employed in this study to compare the paper-based quizzes and gamified e-quizzes in terms of student achievement.

Furthermore, the significance of the relationship between the three paper-based assessments and the three online gamification quizzes, which were used to assess the learning performance of the students at the end of the lectures, was analyzed with Spearman's correlation. Finally, the relationship between the sub-variables (behavioral, emotional, agentic and cognitive engagement) was also analyzed using this correlation.

With respect to qualitative data collection, personal semi-structured interviews (See Appendix 2) were employed to obtain in-depth information about the students' dependent variables (engagement), which had not been fully covered in the quantitative analysis. A thematic analysis procedure was employed to analyze the interview data in order to generate possible themes or categories based on the objectives of the study (Braun, Clarke, Hayfield, & Terry, 2019, pp. 843–860). Besides this, the NVivo qualitative software program was utilized during the transcription, coding, and organizing of the thematic analysis.

3. Quantitative results

3.1. Paper-based quizzes°

Traditional-based lecture and paper-based quizzes were conducted repeatedly in the classroom three times during the intervention period (Weeks 2, 4, and 6). A nonparametric test was applied since the data was not normally distributed ($p < .05$ in Kolmogorov-Smirnov test and skewed histograms). The academic performance of participants from each group is summarized in Table 1. In each assessment, there was an improvement in the mean of the three groups. Differences in the learning performance of students caused by variation in the methods of instruction were identified using the Kruskal-Wallis test analysis. Although the mean scores of the three groups were significantly different in paper-based Assessments II and III ($p < .05$), there was no significant difference between their mean scores in Assessment I.

Post-hoc pairwise comparisons tests were administered to determine which pairs of means were notably different from each other. In the case of Quiz I, the overall assessments showed no significant difference across samples (Fig. 5). The results indicated that there were no statistically substantial differences among all groups in Quiz I (all median scores were 75, $p > .05$).

In paper-based Quiz II, the mean scores of participants in Group 2 were significantly higher than those for Group 3 (b > c, $p < .05$; Table 1). At the same time, no significant differences were found between Group 1 and Group 3 in this phase of assessment (a = c, $p > .05$, Table 1). In Quiz III, the mean scores of participants in Group 2 also revealed statistically substantial differences compared to Group 1 and between Groups 2 and 3 (b > a, b > c, $p < .05$; Table 1). However, no significant difference between Group 1 and Group 3 was detected (a = c, $p > .05$; Table 1).

These results regarding students' in-class academic assessment suggested that the paper-based quizzes facilitated Group 2 students' learning performance more than that of Group 3. Although no significant group differences were consistently found across all the three paper-based quizzes, the participants in Group 2 demonstrated the most improvement from all the three conventional quizzes and earned the highest mean scores on assessment as a whole among the three groups, followed by Group 1.

Table 1
Comparison of group differences in academic performance for each paper-based quiz based on descriptive statistics, Kruskal-Wallis, and post-hoc test.

Groups	*N*	Paper-based quiz I			Paper-based quiz II			Paper-based quiz III		
		M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*
a. Group 1	31	74.68	5.62	75	84.84	4.18	85	85.97	4.73	85
b. Group 2	33	74.24	6.63	75	88.03	5.14	85	90.00	6.25	90
c. Group 3	30	74.00	5.32	75	82.83	5.83	85	85.83	5.27	85
Kruskal-Wallis test		*df* = 2, *p* = .898			*df* = 2, *p* = .001*			*df* = 2, *p* = .004*		
Post-hoc pairwise comparisons					a = c (*p* = .667)			a = c (*p* = .999)		
					b > c (*p* = .001*)			b > a (*p* = .008*)		
					b > a (*p* = .044*)			b > c (*p* = .018*)		

*$p < .05$.
Notes: Paper-based Quiz I: Volcanic eruptions and landslides; Paper-based Quiz II: Flooding and illegal lodging; Paper-based Quiz III: Earthquakes and tsunami.

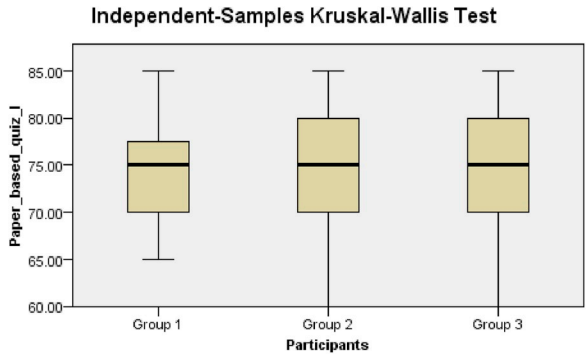

Fig. 5. Independent-Sample Kruskal-Wallis Test for the paper-based Quiz I.

3.2. Gamified e-Quizzes

The weekly gamified e-quiz performance of students in the three intervention groups was examined to answer the first research question. Three different gamified platforms (Socrative, Quizizz, and iSpring LMS) were employed. Gamified learning instruction and gamified e-quizzes were conducted repeatedly in the classroom three times during the intervention period (Weeks 3, 5, and 7). The academic performance of participants in the gamified e-quizzes is summarized in Table 2. Differences in quiz performance due to variation in the gamification platforms were identified using the Kruskal-Wallis test. While there were no significant differences in the mean scores of the three groups for e-Quiz I ($p > .05$; Table 2), the mean scores of the three groups were significantly different for e-Quiz II and e-Quiz III ($p < .05$). This is probably because the students in each group were not familiar with the initial gamified e-quiz assessment, new instruction, and gamification platforms at the beginning of the quiz task. As a result, there was no significant difference between the three groups in Quiz I. The fact that the students were involved in a fun competition when answering the quiz questions and were exposed to an iterative instructional cycle may account for the significant differences in e-Quizzes II and III.

To identify the mean pairs with significant differences, post-hoc pairwise comparison tests were performed in the analysis. While there was no significant difference between Group 1 and Group 3 and between Group 1 and Group 2 (a = b, a = c, $p > .05$; Table 2) in e-Quiz II, Groups 1 and 2 (b > a, $p < .05$; Table 2) were found to be significantly different in e-Quiz III. However, there was no significant difference in the mean test scores of Groups 1 and 3 (a = c, $p > .05$; Table 2).

With regard to the first research objective, the results showed that the learning performance of Group 1 (Socrative) and Group 2 (Quizizz) participants? was better than that of Group 3 (iSpring LMS) participants. The Quizizz group had the highest mean scores among the three groups in the assessments, recording the most improvement in all three quizzes, while the Socrative group came next. The findings showed that students could be motivated to improve their learning performance through gamification instruction by engaging in competitions that are exciting and fun.

With respect to the second research question, the Mann-Whitney *U* test was employed to determine whether there were any differences in student learning performance between paper-based quizzes and gamified e-quizzes. There were no significant differences in students' overall learning achievement scores between the paper-based quizzes and gamified e-quizzes (Table 3). Hence, the null hypothesis was accepted. This analysis suggested that paper-based quizzes still perform a significant role in evaluating student learning performance, particularly as formative assessment instruments. From this finding, we believe that combining paper-based quizzes and gamified e-quizzes in one course can potentially make students more engaged in learning and help identify the weaknesses of each form of assessment.

Table 2
Comparison of group differences on academic performance for each gamified e-quiz based on descriptive statistics, Kruskal-Wallis, and post-hoc test.

Groups	*N*	Gamified e-quiz I			Gamified e-quiz II			Gamified e-quiz III		
		M	*SD*	*Mdn*	*M*	*SD*	*Mdn*	*M*	*SD*	*Mdn*
a. Socrative	31	75.16	5.70	75	85.00	6.19	85	85.97	5.07	85
b. Quizizz	33	75.91	6.78	75	86.67	4.62	85	90.30	5.99	90
c. iSpring LMS	30	74.67	5.71	75	83	5.02	82.5	84.17	5.27	85
Kruskal-Wallis test		*df* = 2, *p* = .643			*df* = 2, *p* = .023*			*df* = 2, *p* = .000*		
Post-hoc pairwise comparisons					a = c (*p* = .308)			a = c (*p* = .362)		
					b > c (*p* = .018*)			b > c (*p* = .000*)		
					a = b (*p* = .820)			a > b (*p* = .027*)		

*$p < .05$.
Notes: Topic for gamified e-Quiz I: Volcanic eruptions and landslides; gamified e-Quiz I: Flooding and illegal lodging; gamified e-Quiz I III: Earthquakes and tsunami.

Table 3
Mann-Whitney *U* test results for comparing students' achievement between paper-based quizzes and gamified e-quizzes.

Quizzes	*N*	Mann-Whitney *U* test			
		Mean rank	*U*	*Z*	*p-value*
Paper-based quiz 1	94	90.21	4015	−1.117	.264
Gamified e-quiz 1	94	98.79			
Paper-based quiz 2	94	96.09	4269	-.420	.674
Gamified e-quiz 2	94	92.91			
Paper-based quiz 3	94	97.62	4125	-.818	.413
Gamified e-quiz 3	94	91.38			

3.3. Correlation analysis of learning performance between both types of quizzes

Spearman's nonparametric correlation was employed to determine the relationships between the gamified e-quizzes and paper-based quizzes scores. Table 4 shows that almost all constructs are correlated with each other, implying that the employment of paper-based quizzes after lectures led to students' better grades in the gamified e-quizzes.

3.4. Perceived engagement

In this section of the study, questionnaire surveys were employed to answer the third research question. A nonparametric Kruskal Wallis test was carried out to compare the differences in mean scores between the three groups. Significant differences in the averages of the three conditions were found (see Table 5). For instance, concerning cognitive and agentic engagement, Group 1's mean scores were significantly higher than those of Group 3 ($a > c$, $p < .05$). At the same time, the mean scores of Group 2 were higher than those of Group 3, particularly for behavioral and agentic engagement ($b > c$, $p < .05$). No significant differences were found between Groups 1 and 2 ($a = b$, $p > .05$) for all types of engagement.

3.5. Correlation analysis of the sub-variables of perceived engagement

Spearman's correlation as a nonparametric technique was employed to verify the relationships between the sub-variables of perceived engagement. The analysis found that all types of engagement were highly correlated with each other (Table 6). This suggests that engagement is not a one-dimensional construct, and future studies, as well as practitioners, should consider the different dimensions of learner engagement in the context.

4. Qualitative findings

The qualitative analysis aimed to answer the fourth research question. The findings were categorized according to the types of formative assessment platforms employed. The themes of the interviews are summarized in Fig. 6.

4.1. Socrative

In the interviews, the students claimed that they felt more emotionally engaged in learning through a game-like system – such as a gamification quiz – and experienced feelings of fun, enjoyment, interest, enthusiasm, and curiosity. Many students commented that they enjoyed the use of Socrative because it was more fun compared to their regular classes. This implies that students' enjoyment and fun may be regarded as emotional engagement.

In terms of behavioral engagement, for example, students competed against each other via spaceships or racing cars, or tried to be the first student to complete all the questions in a quiz. Also, the team who completed a quiz in the fastest time with the most correct answers were the winners. This taught the students to work together as a team, to be effective time managers, and to make majority decisions. Besides, students' positive behavior was also shown in their independent learning skills whereby they answered questions

Table 4
Correlation coefficients among/between gamification and conventional quizzes (n = 94).

	(a)	(b)	(c)	(d)	(e)	(f)
(a) Paper-based quiz I	–					
(b) Paper-based quiz II	.035	–				
(c) Paper-based quiz III	.080	.670**	–			
(d) Gamified e-quiz I	.230*	.147	.232*	–		
(e) Gamified e-quiz II	.061	.291**	.257*	.159	–	
(f) Gamified e-quiz III	.157	.395**	.484**	.248*	.792**	–

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5
Descriptive statistics and Kruskal-Wallis test results to compare the three groups in all types of engagement.

Engagement	Groups	Descriptive statistics		Kruskal-Wallis Test		Post-hoc pairwise comparisons
		M (SD)	*Mdn*	*M-rank*	*p-value**	
Emotional	a. Socrative	4.27 (.436)	4	49.85	.001*	a > c (.042*)
	b. Quizizz	4.39 (.496)	4	55.52		b > c (.001*)
	c. iSpring	3.99 (.335)	4	36.25		a = b (.884)
Behavioral	a. Socrative	4.24 (.420)	4	49.03	.002*	a = c (.075)
	b. Quizizz	4.37 (.484)	4	55.82		b > c (.001*)
	c. iSpring	3.99 (.339)	4	36.77		a = b (.612)
Cognitive	a. Socrative	4.26 (.433)	4	50.92	.004*	a > c (.033*)
	b. Quizizz	4.33 (.479)	4	53.67		b > c (.006*)
	c. iSpring	4.00 (.324)	4	37.18		a = b (.999)
Agentic	a. Socrative	4.30 (.452)	4	51.90	.004*	a > c (.016*)
	b. Quizizz	4.33 (.479)	4	53.17		b > c (.007*)
	c. iSpring	3.99 (.335)	4	36.72		a = b (.999)

*$p < .05$.

Table 6
Correlation coefficients among sub-variables (n = 94).

	1	2	3	4
1. Emotional engagement	–			
2. Behavioral engagement	.973**	–		
3. Cognitive engagement	.949**	.918**	–	
4. Agentic engagement	.923**	.907**	.868**	–

**. Correlation is significant at the 0.01 level (2-tailed).

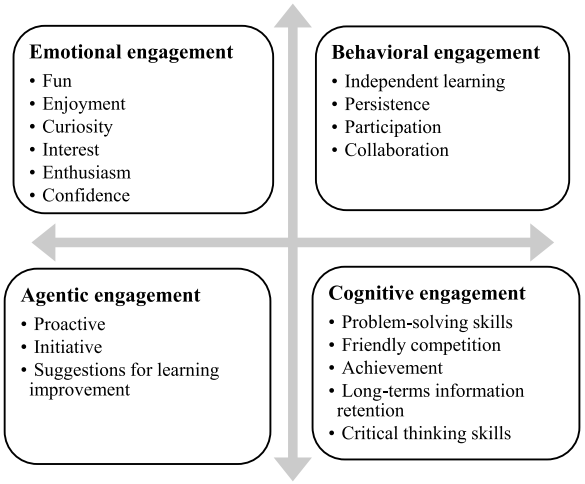

Fig. 6. Thematic results on the students' learning experiences from interviews based on four dimensions of learning engagements.

independently without depending on others. They claimed that they would try hard and not give up when they felt that something was too difficult to do. In learning persistence, for example, the students claimed that the competition activities in the gamified quiz had become a challenge for them to perform better and prove their excellence to others. Apart from this, the students also responded to participation activities and independent learning behaviors positively.

Furthermore, students claimed that they actively participated in the class because they were able to exchange information, solve problems, improve their critical thinking skills, and construct knowledge through their own experience. For example, students acknowledged that they were able to build and improve their teamwork and problem-solving skills through a group competition, a "SpaceRace" game (e.g., *we learn how to work together, collaborate in a competition as a team, and solve a problem together*). Critical thinking was also one of the important skills acknowledged by the students in this application.

Students who agentically engage in the classroom are empowered not only to react passively to the educational environment but also to be proactive in the class. Students stated that they were involved in suggesting improvements in the learning environment. In terms of proactive skills, a particularly interesting statement was: "*I suggested teachers rearranging the groups in every meeting, not with the*

same members". Moreover, the sense of anonymity in Socrative made students more willing to express their opinions in class and participate in subsequent class discussions. It gave shy students a chance to ask their questions, voice their ideas, and reflect on their learning without worrying about their identity. The students were also confident enough to provide some feedback for learning improvement as they were anonymous.

4.2. Quizizz

Students perceived Quizizz as having a positive impact on all types of learning engagement and motivation in class, and they felt that Quizizz enhanced learning performance through friendly competition. This enthusiasm and excitement also led students to greater engagement and, subsequently, to improved learning performance. The interviewees stated that they had fun and enjoyed taking part in a competitive activity. These positive feelings are considered emotional engagement. This finding also implies that interesting activities in the Quizizz application, not only in the form of scores, points, and leaderboards that cater to the spirit of competition but also a funny image or meme appearing after each correct or wrong answer, makes the quiz more fun (Fig. 7). In addition, memes, avatars, themes, and music are also available on this platform to make learning more enjoyable and interesting, and students feel enthusiastic and emotionally engaged. Those not interested in the music are also able to unmute the devices individually according to their needs. A particularly interesting statement was as follows: "*The music on the Quizizz made learning more enjoyable*" and "*The themes provided on this application were very interesting and funny*".

In terms of behavioral engagement, interviewees mentioned that they were able to receive immediate feedback from each quiz question. Students' positive behavior was also shown in their independent learning skills in that; they answered questions independently without depending on others. In this case, the Quizizz application enabled different students to receive the questions in a different order, and this made students' work independently without having any chance to cheat with classmates. Furthermore, the gamified learning activity might also have enhanced students' persistence through a friendly leaderboard competition. The students were able to track their progress on the leaderboard after answering each question and compare their score with others, and this strategy motivated them to persist and succeed in learning. A typical response was: "*I could see other students' scores and we could compete with each other; it has motivated me to do better than others*".

In regard to perceived cognitive engagement, the interviewees acknowledged that they were able to complete each question in time. Students were given 30 s to answer each question. The predetermined time limit given to students to answer each question led to significantly greater gains in students' cognitive ability skills. One interviewee acknowledged, "*I must concentrate to answer each question since the time was very limited*". Students also mentioned that they were involved in a friendly competition. Besides, students in the interview also acknowledged that they had better long-term information retention. When learners were forced to look at information from a different angle, such as through friendly competition, their ability to remember that information long-term improved.

Furthermore, the students agentically engaged through proactive and initiative skills. In terms of proactive skills, for example, some students stated that in order to make the discussion in the class more active, they started holding discussions, and other students subsequently followed this practice. One mentioned, "*I tried to do my best by actively participating in a group discussion during the class*".

4.3. iSpring learn LMS

Most students acknowledged that this application encouraged them to be positively engaged in learning, in terms of independent learning skills. Another student mentioned that the activities on the leaderboard made him work hard in order to show other students that his ranking was better than others (e.g., "*I might show my best scores on the leaderboard to other students so that I needed to work very hard*"). With regard to perceived cognitive engagement, the interviewees reported that they were able to answer each question on time.

Fig. 7. Two memes appear for a correct and wrong answer on the Quizizz platform.

Setting a time limit in the iSpring Learn LMS could help prevent cheating among students, so the teachers set a time limit for completing a quiz. In terms of problem-solving skills, students claimed that they actively participated in class because they were able to exchange information, solve problems, improve their critical thinking skills and construct knowledge through their own experience. For example, students acknowledged that they were able to build on and improve their problem-solving skills through group discussion.

In terms of agentic engagement, students stated that they were able to contribute to creating a learning environment in which deep learning experiences both empowered and benefited them. For instance, the students stated that in order to make the online platform more active, they started holding discussions after completing the quiz to review each question and receive feedback from the instructor.

5. Discussion

The findings of this study indicate that gamified e-quiz exercises work positively to engage students in learning by involving game principles such as points, progressions, badges, competitions, certificates, memes, and leaderboards. The findings also suggest that competition is an important element in gamification implementation in that it provides visible incentives for students' positive earning behaviors. The study showed that quiz competitions after lectures motivated students to compete with one another in the classroom, which in turn led to better scores or performance.

This is in line with numerous studies (Göksün & Gürsoy, 2019; Huang et al., 2018; Jurgelaitis et al.; Huang & Hew, 2018; Lo & Hew, 2018) showing improvements in student achievement through gamification instruction. For instance, Huang and Hew (2018) reported that students in higher education institutions in Hong Kong were motivated to complete significantly more out-of-class activities using gamified instruction. Huang et al. (2018) also reported that students engaged in the gamified class activities were more likely to complete the pre-class and post-class activities on time. The analysis of students' grades reported by Jurgelaitis, Čeponienė, Čeponis, and Drungilas (2019) confirms the view that students' grades can increase as a result of applying gamification in their learning. Indeed, several studies have shown evidence of the positive association between student engagement and learning performance in gamified learning contexts (e.g., Chang & Wei, 2016; de Lope, Arcos, Medina-Medina, Paderewski, & Gutiérrez-Vela, 2017; Göksün & Gürsoy, 2019; Groening & Binnewies, 2019; Kyewski & Kramer, 2018; Çakıroglu, Başıbuyuk, Guler, Atabay, & Memiş, 2017). Çakıroglu et al. (2017), for instance, assert that the use of game-based elements enriches students' academic achievement.

Gamification is recognized as an innovative way of supporting the diverse needs of students with learning or behavioral challenges. de Lope et al. (2017) also maintain that students' active performance and achievement through gamified learning are vital for sustaining high levels of motivation and engagement. The present study implies that there is a positive association between learning achievement and engagement in a gamified learning context: the more students are engaged, the better their achievement. This is in line with a report by Sanchez-Martin and Davila-Acedo (2017), which found evidence of a correlation between game participation, motivation, and academic marks.

Although no significant differences were found in student achievement between paper-based quizzes and gamified e-quizzes in the quantitative findings, the findings from the interviews showed that students perceived gamified e-quizzes in a formative assessment context as fun, motivating and engaging (emotional, cognitive, agentic and behavioral engagement) compared to conventional paper-based quizzes. The study also indicated that students in the Socrative and Quizizz groups were more engaged emotionally (e.g., experiencing feelings of fun, enjoyment, interest, enthusiasm, and curiosity) than students in the iSpring group. However, all three groups showed positive attitudes towards emotional engagement. In terms of behavioral engagement, this result implies that students in the three groups were also positively engaged behaviorally (e.g., paid attention, listened carefully, asked instructors or peers questions and answered instructors' or peers' questions). This might have been due to the availability of tracking points, scores, and badges on the leaderboard in the gamified platforms. With respect to cognitive engagement, this suggests that difficult and demanding tasks are the characteristics of gamification instruction, in that students are required to compete to achieve the highest level and complete more tasks that are difficult. In this study, the learners endeavored to obtain a conceptual understanding rather than a superficial understanding and to use self-regulated learning skills in their activities.

Moreover, this study revealed positive attitudes towards agentic engagement, as seen from the students in the three groups, who were proactive in engaging in classroom activities and attempting to improve the quality of their learning. They also contributed constructively to the learning progress. This shows that the students were trying to enrich the learning activity rather than passively receiving it as a given. These findings are in line with previous studies (e.g., Cagirogulu, 2017; Huang et al., 2018; Huang & Hew, 2018; Lo & Hew, 2018; Tsay et al., 2018) in which gamified learning in diverse classrooms contexts had positive effects on learner engagement. For instance, Lo and Hew (2018) and Huang et al. (2018) found that gamified learning in flipped classroom contexts enhanced students' behavioral and cognitive engagement. The findings of the current study confirmed that gamified learning in a formative assessment classroom context had positive effects on four types of learning engagement: behavioral, emotional, cognitive and agentic engagement (Reeve & Tseng, 2011).

Since this study also attempts to evaluate gamification platforms based on their specific features and evaluation characteristics, we found that the Quizizz platform shows several similarities to the Kahoot game quiz platform, particularly in the form of multiple-choice question type, but each has several different characteristics. Kahoot is a teacher-oriented design that only shows the questions and answers on the teacher's device while Quizizz provides all information displayed on the student's device. Quizizz is different from the Kahoot platform in that it allows students to work from their device both synchronously and asynchronously while Kahoot only allows the asynchronous type of interaction. Another difference discovered between the two platforms is that the Quizizz can be assigned for both homework and in-class activities, and the students can complete their online work at any time. The students in Quizizz were able

to slow down and think about the questions - could shut the timer off completely. The way Quizizz organizes and stores game data is far more user-friendly. We found that a unique feature "Memes" provided in the Quizizz platform, this funny image displayed after a question answered to show whether it was right or wrong.

Furthermore, the Socrative platform can be summarized as a user-friendly tool that allows instructors to initiative a formative assessment through fun quizzes before or after class. A typical question provided is not only in a multiple-choice form but also in also false and true, and open-ended questions. The users can answer quiz questions at anytime and anywhere since no timer times out. Meanwhile, this platform does not provide a leaderboard for the user to track their progress, but it affords with a "SpaceRace" game, where correct answers will move each student's rocket foremost. A Space Race session can foster students' learning engagement through collaborative group work. The students can work collaboratively and subsequently monitor their progress on it. A comparison of each group work can be tracked to see which group is at the forefront and left behind.

For the iSpring platform, an achievement certificate is a creative game feature, which is not provided on other platforms. A certificate will be automatically awarded with printed names on it upon completion of the course or achieve better grades. Besides, unlike the Quizizz platform only allows to create a multiple-choice question and the Socrative program that only provides three types of questions, the iSpring LMS allows users to generate more than twenty types of questions such as matching, multiple-choice, sequence, numeric, drag-and-drop, fill in the blanks, and more. This implies that the iSpring platform shows its strength in providing numerous types of questions, but found its weaknesses in the installation process due to a time consuming and a high price for premium users.

Numerous LMSs incorporating game-elements have been produced as platforms to build, track, and increase learner engagement and drive better learning outcomes. Besides the three platforms analyzed in this study, future researchers in different sectors can employ countless other platforms. By taking advantage of the three-gamification applications, instructors can create a more active learning environment that assists students to reach their potential. It appears that gamified platforms may be the tools to address the old and unsettled question of how to make medium and large lectures more active and engaging for students.

The gamification concept has become an increasingly popular and promising trend in organizations today. According to McGonigal, (2016), these days, gaming has become one of the world's fastest-growing industries globally making a multi-billion-dollar profit, and the market for gamified learning today keeps expanding. Quizizz gamified platforms such as those adopted in this study, for example, are thought have more than ten million users in various institutions around the world. It can be inferred that the gamification concept can be viewed as an innovative part of the technological advancement that can alter the way people interact with technology and the way technology integrates with the contemporary needs of the global market and culture. Finding ways to apply games or game concepts in the classroom can be a promising and innovative tool for educators to engage their students in creative learning skills and attractive competition. We believe that the design of innovative instruction in the educational sector using the concept of gamification may have a very encouraging future in motivating and retaining students' attention, challenging and entertaining them, and most of all in teaching them how to use numerous modalities that are crucial in preparing them to be digital literacy learners.

5.1. Practical implications and theoretical contribution

The results of this study have practical implications for teachers, students, and other educational stakeholders. First, teachers may exploit the innovative nature of gamification platforms, such as those in the present study (i.e., Socrative, Quizizz and iSpring), in order to enhance their students' learning engagement and performance. In this way, they could transform their teaching practice from a conventional teacher-centered approach to a student-centered approach, with innovative instruction and 21st-century skills. Teachers could employ innovative quizzes, such as gamification e-quizzes weekly in the classroom to good effect or after each course to reflect students' understanding of the lessons they have learned. These quizzes could be used after a lecture session or group work in the classroom as a small formative assessment. This would help both students and instructor to identify the progress of the teaching-learning process and to consider whether more focus is needed before moving on to a new topic.

Second, students may be introduced to the concept of gamified learning and gamification applications and benefit from gamified learning in terms of enhanced higher-order thinking skills, engagement, critical and creative thinking, and information and technological literacy skills. Third, the successful implementation of this instruction would benefit educational stakeholders to determine gamified learning and assessment to be a contemporary model of teaching and learning, and recommend its implementation in any educational institution. Finally, this research may help schools in transforming traditional student-centered learning environments and conventional assessments into 21st-century learning environments and innovative assessments.

In terms of theoretical contribution, this research addresses the existing research gaps regarding students' psychological engagement. Research on gamification has rarely discussed student engagement based on four types of learning engagement: emotional, behavioral, cognitive, and agentic engagement (Reeve & Tseng, 2011). In light of this, the present research has contributed to engagement theory through the implementation of gamified learning and formative assessment.

5.2. Limitations and recommendations for future work

The current study has several limitations. First, the analysis of interviews did not report the challenges or limitations of each gamified platform. Second, the sample size of 94 was small. Hence, subsequent studies could involve bigger sample sizes. Likewise, concerning the focus groups interviews, more participants could be involved for information gathering to promote interactivity and allow students to talk about their perspectives regarding issues they find important. Third, we realize that collecting psychological information using questionnaire surveys and interviews can be biased in various ways. Thus, we highly recommend that future studies

investigating psychological engagement or affective learning employ a more objective and complex methodology, including the use of specific apparatus based on artificial intelligence (e.g., emotion sensors, learning analytics, and Collaborative Complex Learning Resource (CC-LR)) to collect student emotional data. Fourth, the usability test on the three-gamification applications was not performed in this study to gather important information on the ease of use of a product. Thus, we recommend that future studies assess game usability and playability, and perform a heuristic evaluation.

6. Conclusion

This study concludes that the employment of innovative gamified e-quiz applications and paper-based quizzes were effective in evaluating students' learning performance, particularly as formative assessment used after the completion of each topic. The three groups were attracted by the gamified instructional approach applied, as they had never experienced it before or in other classes. Moreover, it increased student engagement through the inclusion of game-like features like points, badges, certificate, and leaderboard in non-game contexts. Gamification as a twenty-first-century instructional skill proved to be remarkably influential. The employment of game-like features can be a powerful means to produce more engaging and fun activities in the classrooms. This study has shown that transforming a conventional quiz into a gamified e-quiz by adding challenges, incentives, points, memes, and reward to questions promotes a more engaging and enjoyable experience for learners. Thus, we strongly recommend that further studies be conducted in order to implement such innovative gamified quizzes with other LMS platforms to support students' twenty-first-century learning skills.

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Appendix 1. Questionnaire items of perceived engagement

Construct	Engagement					
No	Potential items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Emotional engagement						
1.	When I worked on gamification quizzes, I felt interested	*1*	*2*	*3*	*4*	*5*
2	When I answered questions on gamification quizzes, I felt curious about the correct answers and my progress scores	*1*	*2*	*3*	*4*	*5*
3.	I thought that this class was fun because of the gamified quiz assessments	*1*	*2*	*3*	*4*	*5*
4.	I enjoyed this class because of the gamified quizzes	*1*	*2*	*3*	*4*	*5*
5.	I felt enthusiastic to participate in a gamified learning activity and gamified e-quizzes	*1*	*2*	*3*	*4*	*5*
6.	I enjoyed learning new things in this class	*1*	*2*	*3*	*4*	*5*
Behavioral engagement						
7.	I listened carefully during feedback sessions	*1*	*2*	*3*	*4*	*5*
8.	I actively participated during feedback sessions	*1*	*2*	*3*	*4*	*5*
9.	I paid attention to other students' questions, comments, and feedback	*1*	*2*	*3*	*4*	*5*
10.	I worked hard to answer quiz questions on the gamification application	*1*	*2*	*3*	*4*	*5*
11.	I was able to collaborate with friends during discussion and feedback sessions	*1*	*2*	*3*	*4*	*5*
12.	I was able to answer quiz questions independently	*1*	*2*	*3*	*4*	*5*
13.	I tried to be active in asking and answering question during the learning process	*1*	*2*	*3*	*4*	*5*
Cognitive engagement						
14.	I was able to track my achievement progress after the gamified quiz activity	*1*	*2*	*3*	*4*	*5*
15.	Gamified e-quizzes were a form of friendly competition	*1*	*2*	*3*	*4*	*5*
16.	I was able to remember the knowledge I gained from the gamified quiz work	*1*	*2*	*3*	*4*	*5*
17.	This class helped me to improve my critical thinking skills through various types of quiz questions	*1*	*2*	*3*	*4*	*5*
18.	We were able to solve any problem related to the quiz questions together in a group during the evaluation and discussion session	*1*	*2*	*3*	*4*	*5*
Agentic engagement						
19.	I let my teacher know what I needed and wanted in order to improve my learning progress	*1*	*2*	*3*	*4*	*5*
20.	I asked questions to make the class more active and lively	*1*	*2*	*3*	*4*	*5*
21.	I reported to the teacher what I liked and disliked from the class activity	*1*	*2*	*3*	*4*	*5*
22.	I proposed suggestions about how to make the class better and not so boring	*1*	*2*	*3*	*4*	*5*
23.	During class, I expressed my preferences and opinions	*1*	*2*	*3*	*4*	*5*
24.	I let my teacher know what I was interested in	*1*	*2*	*3*	*4*	*5*

*Adapted from Reeve and Tseng (2011).

Appendix 2. Interview questions

1. What do you think are the positive effects of Quizizz/Socrative/iSpring Learn LMS platforms?
   a. How was your learning motivation/engagement?
   b. How was your learning achievement?
   c. How was your social interaction?
   d. How were your independent learning skills?
2. What do you think are the positive effects of Quizizz/Socrative/iSpring Learn LMS platforms on your learning achievement?
3. What do you think are the positive effects of Quizizz/Socrative/iSpring Learn LMS platforms on your social interaction?
4. What do you think are the positive effects of Quizizz/Socrative/iSpring Learn LMS platforms on your independent learning skills?
5. What is your opinion about the impact of the feedbacks during the Kahoot/Quizizz/iSpring Learn LMS applications?
6. Which form of quizzes do you prefer? Paper-based or gamified quizzes?
7. Would you like to participate in other courses implementing other types of gamification platforms? Why?

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compedu.2019.103729.

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