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A gamified approach for improving the learning performance of K-6 students using Easter eggs

Yazdan Takbiri[1] · Azam Bastanfard[1] · Amineh Amini[1]

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Abstract
Gamification is mainly used to increase user engagement and motivation, hence increasing the user base and user activity. Defined by applying game elements to non-gaming contexts, gamification is mostly integrated with software applications in order to provide a gameful experience for users. Education has been one of the areas where gamification studies have focused a lot during the last decade. Young students with the age range of 7–12 years old (K-6) require different teaching methods to use their full potential. However, the methods and principles presented in studies on gamification and its application in education are not dedicated to K-6 students. Furthermore, the evolution of video games has brought new opportunities to develop new gamification elements and principles. In this research, the easter egg element has been implemented as a gamification element. Easter eggs can trigger children's curiosity by encouraging them to find all the Easter eggs, promising special rewards and perks. Additionally, a gamified approach is proposed for implementing a gamified software application for K-6 students. Based on the proposed approach, Science Island is implemented as an online gamified web application for K-6 students. In order to assess the proposed approach, a group of 47 sixth-grade students was selected to use the application for an observation period of 2 months. Feedbacks from students showed that more than 82% of the students agreed with the effectiveness of gamification in their educational performance. Additionally, the results from the data analysis revealed that students' learning performance was improved significantly after applying gamification elements; showing an increase of 0.63 in average quiz score from the second month compared to the first month. Furthermore, the user activity rate at the end of the observation period showed increased motivation among students for using the software application.

Keywords Distance education and online learning · Elementary education · Games · Human-computer interface · Improving classroom teaching

✉ Azam Bastanfard
bastanfard@kiau.ac.ir

[1] Department of Computer Engineering, Karaj Branch, Islamic Azad University, Karaj, Iran

1 Introduction

Gamification has become a means of increasing user engagement and improving user's experience in the last decade. It's been mostly used in software applications where its mechanics can be fully used to their potential [35]. Gamification can be used in a wide variety of fields such as online marketing, software apps, healthcare and education [14, 33]. By applying gamification mechanics, organizations are looking for ways to boost their sales and engage customers, while learning platforms are trying to engage students in order to improve their educational performance. Studies on the topic of gamification and education aim to present working methods and frameworks for improving students' learning performance by applying gamification elements to a learning system or proposing new gamified platforms [37]. However, these methods may not be effective for students with different age ranges, and they may lack psychological power when applied to learning platforms for students with a specific age range. Furthermore, some video game elements have gained popularity in recent years, though there's a lack of empirical evidence on how these video game elements can be applied to non-gaming contexts.

With the advancement of technology, young students are more exposed to gadgets and gaming platforms. Therefore, they're more familiar with these concepts than older students. Consequently, traditional learning environments may not suit young students [50]. Also, learning environments for young students need to be in harmony with their taste to encourage studying and learning [5]. Furthermore, new gamification elements can provide an opportunity to take advantage of state-of-the-art game elements and to provide a more dynamic learning experience for younger students. To this end, the goals of this research are defined as the following:

- Present a gamified method for increasing K-6 students' motivation and engagement
- Study the possibility of using new video game elements as gamification elements
- Define guidelines for implementing a software application that is adaptive to young students' psychological needs

In this research, a gamified approach is presented with common gamification elements for the K-6 educational step. The proposed approach is used to implement Science Island; an online learning web application for K-6 students. Furthermore, easter eggs have been presented and implemented as a new gamification element in the proposed software application. By triggering students' curiosity and encouraging them to find all of the easter eggs, students are more engaged with the application and will therefore spend more time on the platform [48]. Increased activity time can potentially increase educational performance in the long term. The rest of the paper is organized as the following: In Section 2 the literature on the topic of gamification and its use cases is presented. Section 3 will demonstrate the proposed method while Section 4 explains the results from the empirical study. In Section 5 the results from the study will be discussed. Finally, Section 6 will conclude the research with some ideas for future research.

2 Literature review

Gamification has been the subject of many studies in the last decade. Defined as applying game elements and mechanics to non-gaming contexts, gamification's main purpose is mostly

increasing user engagement and thus, improving user activity and performance [12]. It has been used in different areas, but mostly, it has been applied to educational software applications [39]. The reason why gamification has gained attention in education is that young students are not very adaptive to old stale classroom environments, and with technology bringing new opportunities, using classic learning methods may not be very useful for the younger generation [31].

There are multiple methods for gamification to be applied in the field of education. Methods presented in studies often target a specific aspect of students' experience regarding education and learning. For instance, [6] demonstrates that using gamified learning encourages students to try new things and avoid the fear to make a mistake. [6] also mentions that gamification in education requires students to participate consistently in order to retain the game-like nature of gamification. Furthermore, [9] aims to generate involvement among students, and increase interest, engagement, and efficiency by applying gamification mechanics to students' learning platform. To evaluate the research, [9] observed 61 students from an elementary school and collected data using observation, interviews, and questionnaires. Additionally, the collected data were statistically analyzed using a multivariant technique known as cluster analysis.

Modern healthcare services make use of software applications to promote and maintain therapy among patients [41]. These eHealth applications help patients keep track of their treatment and follow their treatment plan [17]. However, patients' engagement with the applications grows less if there's no means of motivation [7]. Therefore, gamification can effectively improve the level of medical treatments and therapy when used in eHealth applications, since the lack of engagement throughout a patient's treatment is a common case among these applications [10].

Developing software applications for training and learning is one of the most helpful and challenging roles of computer technology in human-machine interacting systems [4, 32]. Education and learning have been a direct target of gamification studies since they have a great potential for the application of this concept [45]. By introducing game-thinking and game mechanics to the learning environment, gamification provides a dynamic experience for ordinary activities and school tasks [18]. However, students might have different perspectives on gamification and its mechanics [3]. Therefore, applying certain gamification mechanics to educational settings should be done with care in order to prevent motivation drop in students' activity [19]. To this end, students can take part in developing a serious game dedicated to easing the learning process so that the game mechanics are well adapted to students' nature [2]. Furthermore, collecting students' feedbacks from gamification elements and providing a personalized gamified experience can effectively increase students' motivation with different perspectives on gamification elements [34]. However, creating gamified designs is effort-intensive, and personalizing the experience for each user will increase this workload. Consequently, machine learning algorithms can be used for personalized content selection in order to provide a personalized gamification experience to users [25]. Due to the emergence of new technologies and the development of new active methodologies in teaching and learning, education is being renewed constantly [38]. Furthermore, gamification methods must be adaptive to support students' different learning styles in order to prevent the lack of motivation among learners and decrease the drop-out rate [21]. On another note, gamification requires constant refinement over time in order to be useful in incorporating gamification principles into educational activities [40]. Furthermore, gamification can be perceived differently by students of contrasting age ranges [27]. In some cases, an instructor or guide would be needed

to demonstrate different aspects of gamification [24]. Additionally, each gamification element may have a different effect on students from different majors, meaning that students who majored in statistics may have a different view towards challenges than those who majored in computer science [29].

Framing an activity as a game by introducing game mechanics can increase intrinsic motivation as much as a video game itself [30, 36]. Gamification can promote psychological outcomes that refer to psychological experiences including competence, autonomy, relatedness, enjoyment, and engagement [26, 47]. Certain psychological principles need to be considered in order to implement a gamified application that has a positive effect on user engagement and motivation. For instance, quantitative measurements like points, leaderboards, and levels can have a positive effect on user participation, though these elements may increase users' extrinsic motivation in the short-term period, meaning that they cannot guarantee the same positive effect in the long-term period [49].

Gamified applications provide a gameful experience to users. This gameful experience is created by elements such as points, badges, levels, and leaderboards [11]. The positive belief on the effectiveness of gamification has been based on the conception that since games are fun and intrinsically motivating, then services that take advantage of game mechanics are also fun and effective in invoking positive behavioral outcomes [15]. However, the effectiveness of gamification elements on intrinsic motivation levels is dependent on how these elements and mechanics are implemented [16]. Therefore, certain principles and guidelines regarding mechanics, dynamics, and emotions must be considered in order to provide a gamified experience for users [42]. The majority of gamification implementations are dedicated to marketing since users are creators of value and engaging them to use a service can create more value for that particular service [23]. Furthermore, organizations are adopting gamification practices to increase customer engagement. To this end, [52] presents a model that examines the effect of gamification on customer engagement and their attitude towards the organizational brand. Furthermore, [20] provides insights into the implementation flaws deriving from gamification by using Samsung Nation as a unit of analysis. Additionally, [13] reveals that gamification principles promote hope, indicating that hope is more strongly associated with customer engagement than the psychological condition of compulsion. Customer engagement can also be achieved through gamified loyalty programs [22]. Furthermore, [22] mention that loyalty program members' intrinsic and extrinsic motivation are the drivers of gamified loyalty programs, which impacts customer brand engagement value.

Digital easter eggs are features and reference buried deep in software applications and other media [51]. Easter eggs in software have a long history. They've been inside the first programming languages, operating systems, and software applications. They've mostly been used in the context of games, though their application in the non-game context is not clear [28]. Furthermore, it is observed that easter eggs in digital games can extend the game narrative and motivate players to replay the game [44]. Easter eggs help bring more color to any work, providing a more joyful experience for users [43]. Easter eggs can have multiple use cases. They can be just a reference or feature that may sound interesting to users, or they can have special rewards if the user manages to find them [8]. Additionally, easter eggs can be used to engage classroom learners by adding a game-like element to the learning procedure [46]. In this research, easter eggs are introduced as a gamification element, implemented in the form of treasure chests, encouraging students to find them all for an ultimate prize. Students would be asked to learn the topics for the main three courses of elementary school

(Mathematics, Literature, and Science) via available tutorials and take part in online quizzes during a two-month observation period.

3 Methodology

As mentioned in the literature review section, easter eggs in technology are references and hidden objects with metonymic meanings. They can be references to pop culture, science, literature, or anything that is unrelated at first sight, but contains a meaningful connection to the topic if looked closely. This fact creates a sense of curiosity in users to find the easter egg references at first, and figure out the connections in order to extract a valid understanding. Additionally, easter eggs can reward the user with special treatments should the user find all of them or a specific amount defined by the developers. Based on their nature and behavior, easter eggs can be used in learning platforms as a gamification element with students as the audience. Easter eggs provide a chance to trigger students' curiosity by encouraging them to find all the easter eggs for a reward. Students will have to use the application more often and carefully, in order to find all the easter eggs. Therefore, students would spend more time with the application trying to find the easter eggs which leads to increased user activity. Consequently, using easter eggs as gamification elements can result in improved user engagement and it can effectively increase user activity in a learning platform. The easter egg concept proposed in this research is introduced as a new gamification element, hence, it has not been used in any prior studies.

3.1 Platform

In order to collect data for the evaluation phase of the proposed method in this research, Science Island, an online learning web application is implemented that contains most of the well-known gamification elements, including points, coins, levels, leaderboard, badges, and avatars, as well as easter eggs. Students can sign up for a user account to access the application features, or as used for the evaluation purpose of this research, the system administrator can create user accounts in bulk and provide students with their user authentication credentials. After the sign-up process, students can log in via the username and password provided to them and take advantage of the gamified learning experience. Figure 1 shows the dashboard for a student's panel containing information about activity and gamification elements.

Science Island contains online tutorials and quizzes for three main lessons in the elementary school course including science, mathematics, and literature. Students are encouraged to use the tutorials to learn the topics and participate in the quizzes to evaluate their understanding of the topic. These online quizzes have no limits in the number of executions, meaning that the students can take part in a quiz as much as they want. Also, the quiz score for each topic will be the maximum score the student has achieved in that quiz. Therefore, students can participate in quizzes without having to worry about consequences such as failing and low quiz scores. Furthermore, they can earn coins by answering correctly each time they participate in a quiz. Consequently, students earn more coins through consistent and rapid participation, allowing them to buy more items from the online store.

In order to link a connection between the title of the application and the easter eggs in Science Island, the Easter eggs have been designed as treasure chests. These treasure chests

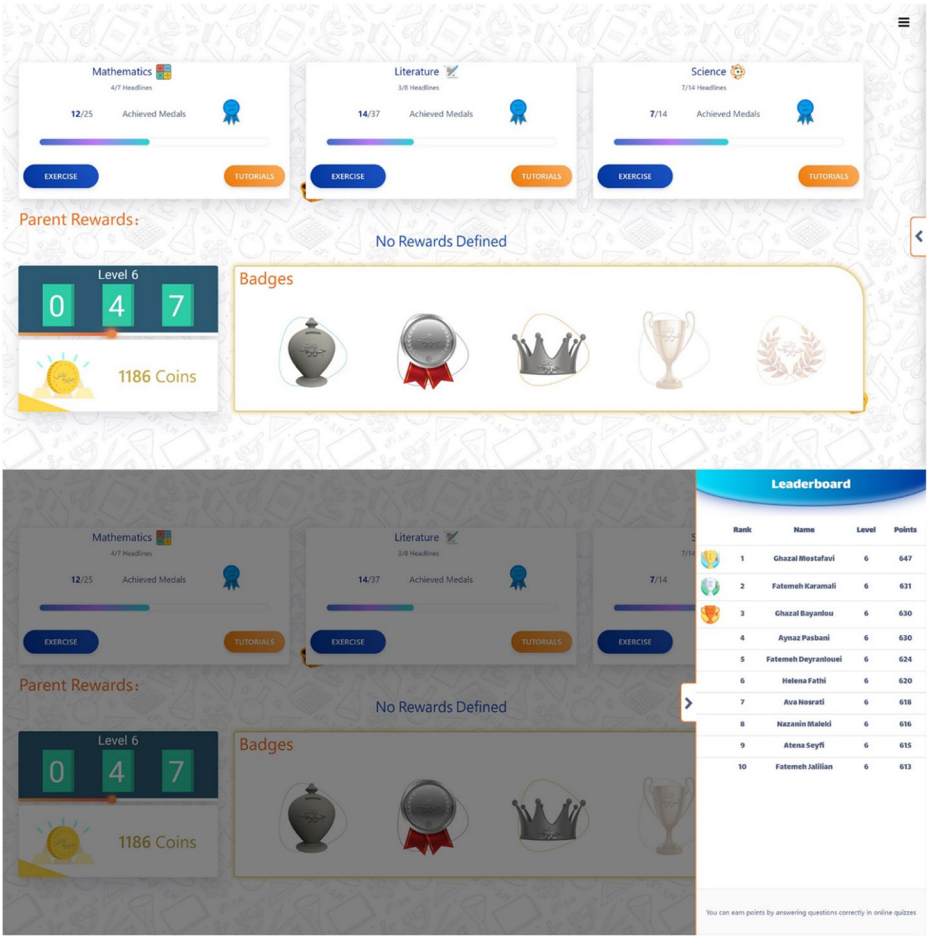

Fig. 1 Student's panel dashboard

have been scattered around all pages of the web application. Figure 2 shows some of the treasure chests.

There are 20 treasure chests in total. 8 treasure chests have been hidden in public pages of the panel, while 12 treasure chests have been hidden in quiz pages. Therefore, students have to take part in quizzes in order to find all the treasure chests. Students are rewarded with something special for every 5 treasure chests they find. These rewards are only achievable via treasure chests and there are no other ways to unlock them. Table 1 shows the perks students get for finding treasure chests.

At students' first log in to their gamified panel, a dialog is shown that introduces the gamification elements implemented in the application. At this point, students are introduced to the gamification mechanism, application features including tutorials and videos, and the overall procedure of using the application. After finding the first treasure chest, students are informed about the treasure chest entity via a pirate-themed screen that contains the required explanation and description behind them. The description provided in this screen explains the perks and rewards achievable by finding the treasure chests.

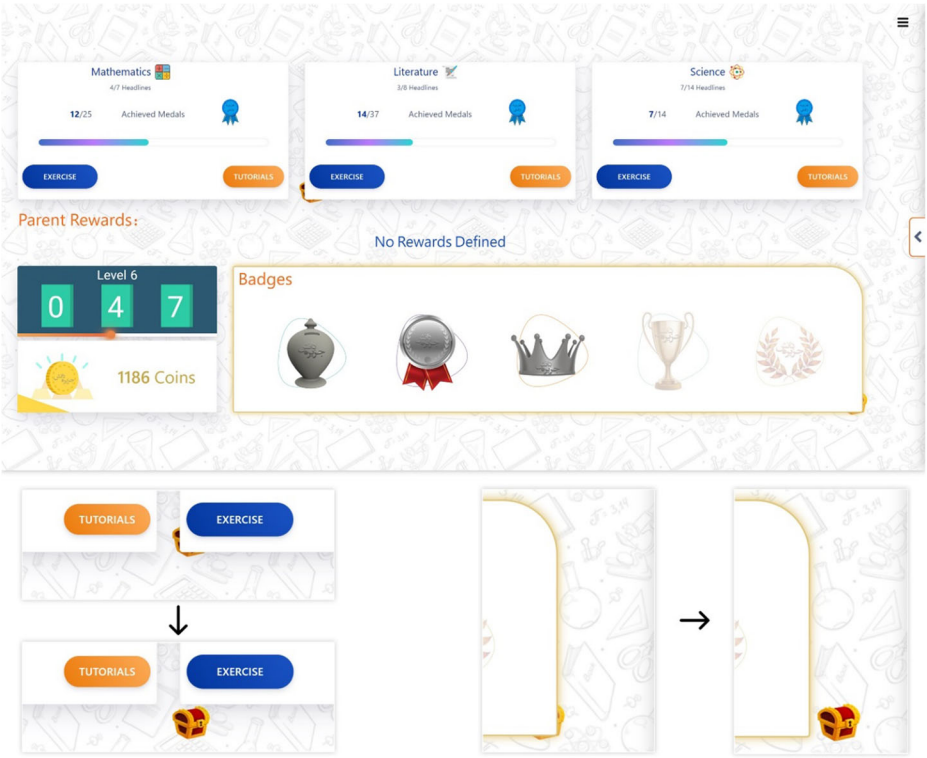

Fig. 2 Hidden treasure chests in student's panel

When the students log in to their panel for the first time, they would only have access to tutorials and online quizzes, meaning that gamification elements would not be available at this stage. In order to gain access to gamification elements, students must pass 6 quizzes. Students should achieve a minimum score of 70 to pass a quiz. Figure 3 shows the student's activity pseudocode for this stage of the data collection step.

After passing 6 quizzes, gamification elements would become available for the student. At this stage, the student would go on to explore the gamified panel until he/she has passed 12 quizzes. Figure 4 demonstrates the student's activity pseudocode for the gamified stage of the data collection step.

After passing the twelfth quiz, the student will be prompted about the effect of gamification on activity and engagement levels via a dichotomous question. If the student agrees with the effectiveness of gamification on his/her learning performance, he/she will have access to gamification elements for the rest of the observation period. If the student disagrees with the

Table 1 Treasure chests perks

Treasure chests count	Perks
5 chests	1st unique avatar pack +50 coins +50 points
10 chests	Dark theme +150 coins +100 points
15 chests	2nd unique avatar pack +200 coins +200 points
20 chests	Pirate and Island Themes +500 coins +500 points

```
1. while (successful quizzes < 6)
2.     Watch the tutorials for a topic
3.     Participate in an online quiz
4.     Get quiz results
5. endwhile
```

Fig. 3 Activity pseudocode for the non-gamified panel

effectiveness of gamification, his/her access to gamification elements would be limited and the student would be able to continue through the observation period by using the online tutorials and quizzes.

3.2 Participants

The evaluation method proposed in this research requires real data and empirical evidence. For this matter, a group of 47 male and female sixth-grade students were selected to participate in the evaluation phase of this research. Based on the comments from their teachers and their prior grades in the classroom, it is observed that students vary in their level of educational performance, regardless of gender.

During a meeting, the students were informed about the experiment and asked about previous experiences using online learning platforms. Their feedback showed that none of the students had any experience with gamified or non-gamified learning platforms. They were also informed that their performance in this experiment would not have any negative effect on their classroom grades. Furthermore, the application functionality and the experiment procedure were fully described to students, leaving no questions unanswered. Additionally, a help page was designed to assist students with their activity should they lose their way. Also, an

```
1. while (successful quizzes < 12)
2.     Watch the tutorials for a topic
3.     Participate in an online quiz
4.     if (answered a question correctly)
5.         Gain points and coins for correct answers
6.             if (points are enough for level-up)
7.                 Level-up
8.             endif
9.     endif
10.            Get quiz results
11.            if (qualified for a badge)
12.                Get the appropriate badge
13.            endif
14.            if (found enough easter eggs for easter egg perks)
15.                Get easter egg perks
16.            endif
17.        endwhile
```

Fig. 4 Activity pseudocode for the gamified panel

online messaging platform was developed and integrated with the application to provide support and guidance, in case students need it.

3.3 Evaluation

To evaluate the proposed method, a group of 47 sixth-grade students was selected to participate in a two-month observation program. The students would continue to use the application during these two months, and their activity records will be used to assess the effectiveness of the proposed method. The evaluation phase of this research is done in 3 steps demonstrated in Fig. 5.

The data collection step would be done via the implemented platform. The students would go on to use the platform for learning topics and participating in quizzes while interacting with gamification elements. Their activity records would be logged to be used for statistical and clustering analysis. As for subjective evaluation, students would be asked about the effectiveness of gamification via a dichotomous question and their responses would be logged for analysis. Furthermore, students' learning experience would evolve and change based on their interaction with gamification elements and their learning performance, creating a personalized gamified experience.

Subjective evaluation is the first step of the evaluation process. At this stage, students' feedback regarding the effectiveness of gamification would be collected via an online survey question after passing 12 online quizzes. Furthermore, it is possible for some students not to answer the survey question. This event happens if a student didn't participate in the adequate number of quizzes for the survey to show up. Therefore, there are three values for the data collected at the subjective evaluation step: 1) Effective, 2) Not effective and 3) No answer.

The data used for statistical and clustering analysis is collected at four specific events, meaning that there are four datasets available for analysis. The first dataset consists of students' activity logs after participating in six quizzes, where they are introduced to gamification for the first time. The second dataset contains the data for students' activity after participating in

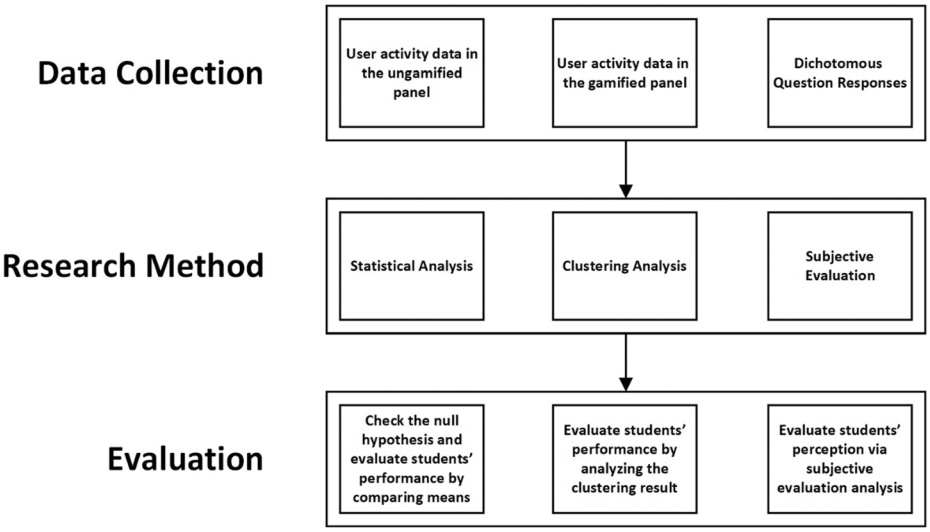

Fig. 5 Research evaluation steps

twelve quizzes. At this point, students have had considerable interaction with gamification to be asked about its effectiveness via the questionnaire. The time frame that the first two datasets have been created is considered short-term. After answering the survey question, students would continue using the platform for one month, during which the third dataset is collected. This procedure would continue for another month to complete the two-month observation period and extract the fourth and final dataset. Since the time span of the third and fourth datasets is wider than the first two, the time frame of the third and fourth datasets is referred to as long-term.

The collected data consists of two variables: 1) Activity and 2) Quiz score. The activity variable is an indication of the time students spend on the platform. Higher values for the activity variable show more dedication and engagement among students. The quiz score variable is a way of assessing students' learning performance. If the learning experience is more joyful and engaging for students, an increase in quiz scores can be expected.

In order to analyze the collected data, a student's t test would be conducted to validate the data. The null hypothesis is then checked to ensure data validation and consistency. Furthermore, a clustering analysis using the DBSCAN algorithm is conducted to categorize student behavior and performance after being exposed to gamification.

Conclusively, the results from the clustering analysis would be demonstrated to discuss the progress of students' performance during the observation period. It is expected to observe an increase in students' performance as they gradually interact with gamification elements.

4 Results

During the 2 months observation period, the students would go on to explore their panel and take advantage of the learning content and gamification elements altogether. In this section, variables related to students' performance and activity will be analyzed in order to confirm and demonstrate their correlation. Therefore, the results of subjective evaluation, statistical analysis, and clustering analysis, as well as threats to the validity of the experiment will be covered in this section.

4.1 Subjective evaluation

After 12 successful quizzes, students were asked if gamification elements had a positive effect on their activity, engagement, and performance via a dichotomous survey question. Students' responses to the survey question provide deep insight into how they perceived gamification and how much they found it helpful. Figure 6 demonstrates the responses to the survey question.

The data in Fig. 6 shows that more than 82% of the students responded that gamification elements had positive effects on their learning experience and performance, whereas only 1 student disagreed with the effectiveness of gamification on performance and activity. Furthermore, 7 students did not answer the survey question, meaning that they didn't participate in the adequate number of quizzes to be able to respond to the survey question.

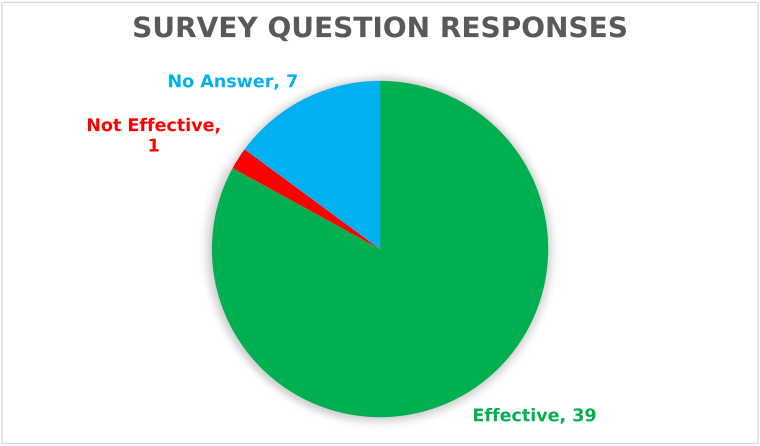

Fig. 6 Questionnaire responses

4.2 Statistical analysis

The null hypothesis is based on the fact that there's no effect on the population. If the null hypothesis is accepted, it can be perceived that the proposed method did not have any effect on the population. On the other hand, the alternative hypothesis claims that there is an effect on the population. Therefore, we aim to provide data to reject the null hypothesis to demonstrate that the proposed method had an impact on the participants. To check if the null hypothesis is accepted or rejected, the p value for each dataset needs to be calculated. This can be achieved by performing a student's t test on the datasets. If the p value for a dataset is below 0.05, we can conclude that the null hypothesis is rejected.

In order to determine if students' performance has improved during the observation period, a student's t test has been conducted on 4 datasets. Each dataset contains two columns that represent different time periods. The student's t test has been conducted for 2 variables in 2 time frames. The variables include "Average Activity" and "Average Quiz Score". "Average Activity" is the average number of times the student has logged in to his/her panel, while "Average Quiz Score" is the overall average score the student has achieved. The "Average Quiz Score" is a dependent variable that relies on students' activity, making the "Average Activity" variable independent. The values for these two variables have been presented in both short-term and long-term time frames. The short-term time frame consists of the time before and after applying gamification to students' panels, whereas the long-term time frame belongs to the first month and the second month of the observation period. Table 2 demonstrates the results from the student's t test on datasets.

Table 2 Student's t test result

Dataset	Time Frame	Mean Difference	t	df	p value
Average Activity	Short-term	.65574	7.721	46	7.659E-10
Average Activity	Long-term	.48489	7.534	46	1.4487E-9
Average Quiz Score	Short-term	.66638	3.956	46	2.62E-4
Average Quiz Score	Long-term	.63298	5.981	46	3.0961E-7

Based on the data shown in Table 2, it can be observed that the p value for all datasets is less than 0.05. Therefore, the null hypothesis is rejected, meaning that there is a significant difference between means in each dataset.

Each of the online quizzes in Science Island contains 10 questions. Student's score will increase by 1 for every correct answer. Therefore, students' quiz scores would be a number between 0 and 10. To this end, students will be categorized into 3 groups based on their quiz scores. Students with the score between 0 and 4 will be categorized as weak, while students with the score between 4 and 7 are categorized as average and students who achieve a score more than 7 will be categorized as good.

4.3 Clustering analysis

To evaluate the effectiveness of gamification on students' performance and activity during the observation period, the data fetched from the Science Island database in 4 time frames are clustered using the DBSCAN clustering algorithm. DBSCAN is a density-based clustering algorithm. Density-based clustering algorithms can discover clusters with arbitrary shapes and detect noise [1]. After analyzing the clustering results of the datasets using multiple clustering algorithms, it was observed that the DBSCAN clustering algorithm had the best clustering results compared to other methods due to its ability to detect noise in the data. The datasets dedicated to clustering contain Average Activity and Average Quiz Score variables. Furthermore, the dataset time frames include the variable values from before applying gamification, after applying gamification, first month, and the second month of activity. The aim of performing clustering analysis has been to observe the progress of students' educational performance by monitoring the cluster size for the Average Activity and Average Quiz Score variables. The clustering plot for students' activity data before applying gamification with the clustering parameters shown in Table 3 is demonstrated in Fig. 7.

Based on the clusters and data values shown in Fig. 7, it is observed that none of the students are categorized as weak. The reason for this matter is because the data point that has the lowest quiz score value has a quiz score of more than 4. At this stage, students are still not well enrolled in the application. Therefore, the values for Activity are mostly equal to 1, meaning that students log in to their panel once a day on average. The values for the Average Activity variable are expected to increase as gamification is added to the students' panel. Figure 8 shows the clustering plot for students' activity data after applying gamification with the clustering parameters shown in Table 4.

The data points in Fig. 8 are more scattered than the data points in Fig. 7. At this stage, an increase in students' average activity values can be observed. Furthermore, the number of datapoints belonging to the blue cluster has decreased, leading to increased red cluster size. This increase in activity values can be due to the effectiveness of gamification in engaging students and helping them improve their performance. Additionally, the clusters have segregated the data points based on the categorization threshold. Therefore, the blue clusters are considered average students, while the red cluster contains data points for students with good

Table 3 Clustering parameters for students' activity data before applying gamification

Dataset	MinPts	EPS
Before Gamification	3	.35

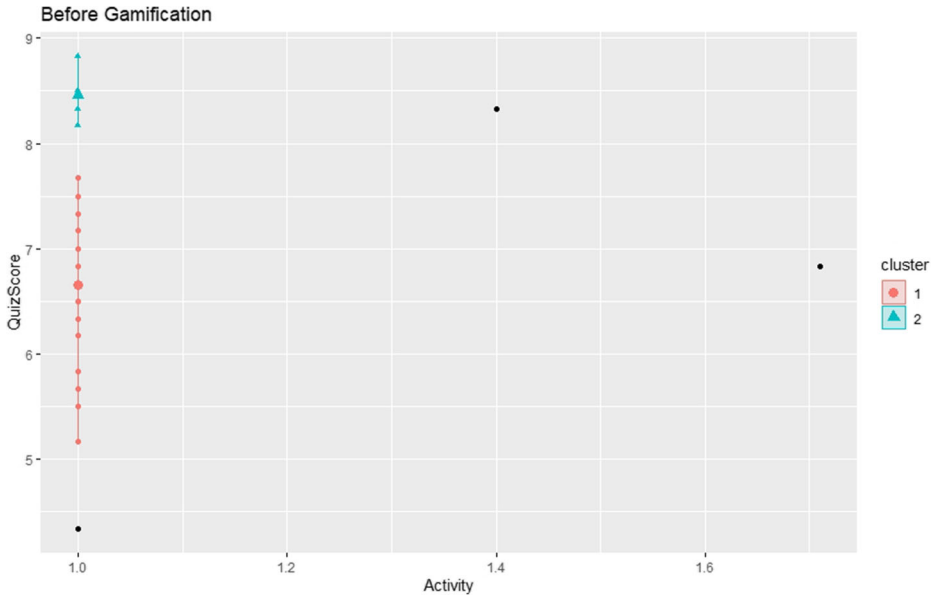

Fig. 7 Clustering plot for students' activity data before applying gamification

performance. However, the distance between clusters is not much, which indicates that there is not much difference between the average activity of average students and students with good performance. The clustering plot for students' activity data in the first month with the parameters given in Table 5 is shown in Fig. 9.

Comparing the data values in the blue cluster in Fig. 9 and Fig. 8 shows that over time, students' average quiz score has increased, which can result in improved learning

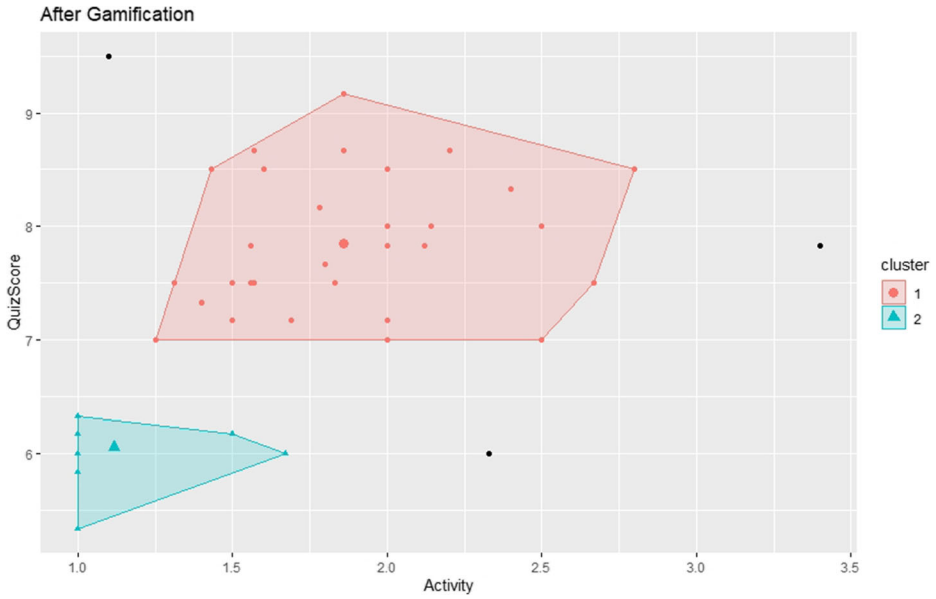

Fig. 8 Clustering plot for students' activity data after applying gamification

Table 4 Clustering parameters for students' activity data after applying gamification

Dataset	MinPts	EPS
After Gamification	3	.53

performance. At this stage, students have used gamification elements for a while, and the positive effect of gamification on their activity rates can be observed in Fig. 9. Consequently, the horizontal distance between clusters has increased compared to the distance between clusters in Fig. 8. Finally, the clustering plot for students' activity data in the second month with the parameters available in Table 6 would draw a conclusion to the effectiveness of gamification in students' learning performance.

The cluster sizes in Fig. 10 show a significant increase in the size of the red cluster, meaning that a large number of students are now categorized as students with good performance. Even though there are some data points in the blue cluster representing average students, their count is much smaller compared to the data points in the red cluster.

4.4 Threats to validity

The threats to validity and countering them are an essential part of experiment design. In this section, details about the threats to validity and the counter-action proposed in the designed experiment of this research are discussed.

History The results of the experiment should solely depend on the proposed research method. In order to counter the threat by history in the proposed experiment, students were fully informed that their activity and performance in the experiment would not have any negative effects on their classroom grades during the introduction meeting.

Maturation The threat by maturation in this experiment would be if students had no previous knowledge of the platform when they were first introduced as the participants in the experiment. Therefore, the implemented platform proposed in this research was fully described during the introduction meeting. At this stage, the functionality of the implemented platform was explained to the students so that they had a general knowledge of working with the platform. Additionally, the students were also informed about the experiment design, its steps, and its timings.

Instrumentation To counter the threat by instrumentation in this experiment, the timings for the data collection step of the evaluation phase were created in equal periods. For the short-term timeframe, the values for the variables were collected after students passed 6 and 12 quizzes. As for the long-term timeframe, the values were collected at the end of the first and the second month of the experiment.

Table 5 Clustering parameters for students' activity data in the first month

Dataset	MinPts	EPS
First Month	3	.37

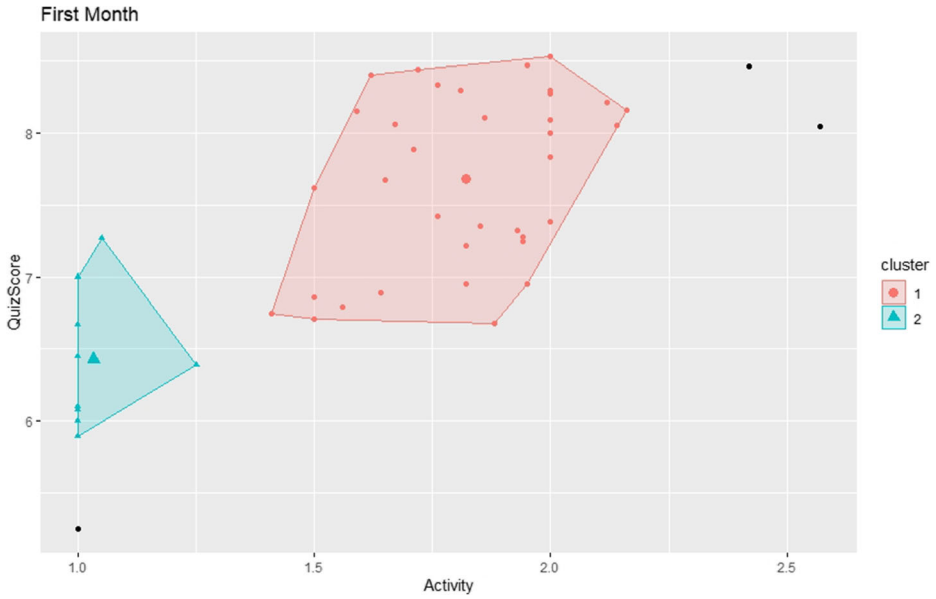

Fig. 9 Clustering plot for students' activity data in the first month

Testing The Quiz Score variable which is one of the main variables in the evaluation of this research is calculated by the number of correct answers to the questions in an online quiz. In order to counter the threat by testing, each quiz had different questions. Furthermore, students' highest quiz score in each quiz would count toward their progression throughout the experiment, meaning that repeating a quiz multiple times would not count as multiple quiz participation.

5 Discussion

The evaluation phase of this research was performed using three methods. First, students' feedback was collected via a questionnaire that was shown in the students' panel after they've succeeded in 12 quizzes. Based on the chart data in Fig. 6, the majority of students had positive feedback about the role of gamification in learning performance. After analyzing the feedbacks count, it was observed that a small group of students (N = 7) did not answer the questionnaire, thus they did not provide any feedback. The reason why these students did not answer the questionnaire is that they did not participate in enough quizzes for the questionnaire to be shown. Also, the activity data for these students show that they were the least active ones among all 47 students.

Statistical analysis can provide useful information about the data and demonstrate its validity. Therefore, student's t test was performed on the data fetched from the software

Table 6 Clustering parameters for students' activity data in the second month

Dataset	MinPts	EPS
Second Month	3	.42

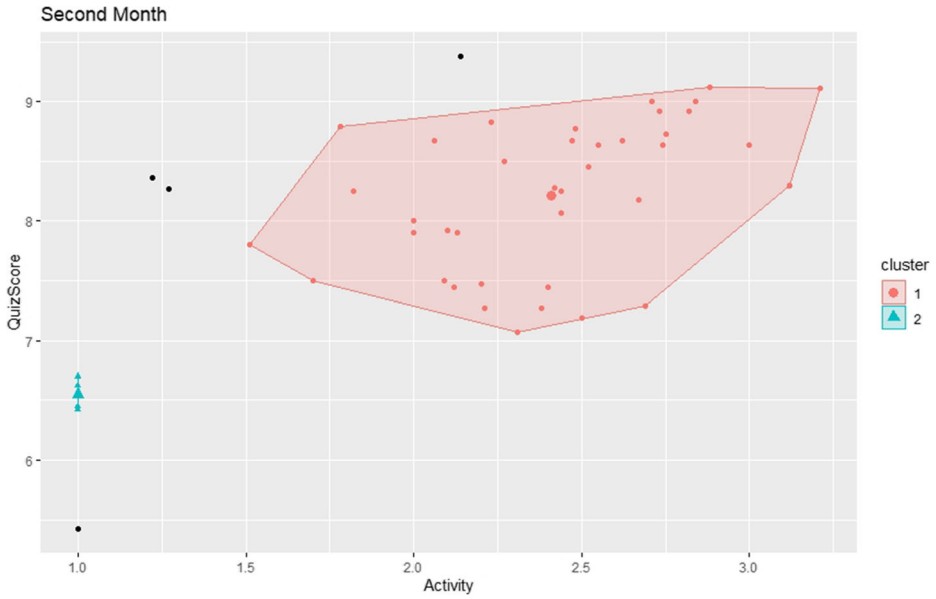

Fig. 10 Clustering plot for students' activity data in the second month

database. The results from the t-test analysis revealed that the mean differences for both variables in both time frames are positive numbers. This indicates that the values for the variables have increased with time, pointing towards the fact that students' performance has improved during the observation period.

As mentioned in section 4, clustering analysis has been conducted in order to evaluate the effectiveness of gamification on students' performance. The clustering results showed that most of the students had a better performance when exposed to gamification. Furthermore, gamification has played a major role in increasing students' activity and quiz scores after the first month. Students had better learning performance in the second month, hence, most of the students who were categorized as average students based on their grades in the first month, categorized as good students in the second month.

After two months of activity in Science Island, students who agreed with the positive effect of gamification and had access to gamification elements had a significant improvement in their average quiz score and average activity values. Those students who disagreed or did not answer the questionnaire were mostly categorized as average students. Therefore, we can conclude that gamification has effectively improved students' performance and engagement levels and it has increased the activity rate in the observation period.

6 Conclusion and future work

Gamification has had a great impact on improving the learning performance and educational outcome of students. Most studies around gamification and its role in education, present methods and frameworks for integrating gamification into educational platforms. In this research, a comprehensive study was conducted to evaluate the effect of common gamification elements on K-6 students. Furthermore, easter eggs were implemented as a gamification

element in the proposed software. In order to evaluate the proposed method, a group of 47 sixth-grade male and female students were selected to use the application for 2 months. During this period, students would go on to experience both gamified and non-gamified panels, which they would then send feedbacks regarding each of the panels. Additionally, statistical and clustering analyses were conducted on the datasets extracted from the application's database containing the activity logs for all students. The results from the feedbacks showed that more than 82% of students had positive feedback regarding the effect of gamification on learning performance. Furthermore, the statistical and clustering analysis showed significant growth in user activity and quiz score rate, meaning that the proposed approach and the addition of easter eggs as gamification elements have effectively increased user engagement and students' learning performance.

Due to the Covid-19 restrictions and executive educational organizations not cooperating with this research, the sample size was small and the observation period was short. Furthermore, a few numbers of students had negative feedback on the effectiveness of gamification on learning performance. Therefore, a larger group of students is recommended to be studied with the proposed approach during a longer period in order to further assess the impact of easter eggs as a gamification element in future researches.

Data availability The datasets generated and analyzed during the current study are available on reasonable request.

Declaration

Conflict of interest The authors do not have conflict/compete interest. This research work has not been funded by any organization.

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