Gamification of STEM-based Evaluation Software on Online Learning for Elementary School Students

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Abstract

The impact of the Covid-19 virus cases continues to increase and impacts many lives, including young children. Schools are closed, and students are studying from home. Using online platforms is advantageous because it helps the teaching and learning process. Even though it is online learning, must be evaluated students' work. Similar research has occurred in vocational education but is considered boring and has not been standardized. This study combines gamified Software as a practical application among lower primary students to provide interesting evaluations on STEM learning, which is considered helpful for evaluation for many schools. We built the Software using a 6D framework with stages of development, starting from determining business goals and describing the target's behavior until deploying the Software. The evaluation period was carried out for 7 days using 30 respondents by analyzing Pre-test Vs. Post-test and activity logs. The results individually showed significant improvements in science, technology, engineering, and mathematics, with an average of more than 20% and 13%, respectively. Finally, through this study, we confirm that carefully designed gamified Software for lower primary school students has helped achieve non-gaming-related goals and improved evaluation techniques for online learning.

Keywords
Gamified Software, 6D Framework, STEM-based evaluation, COVID-19, Learning-form-home

1. Introduction

The Covid-19 pandemic that occurred at the beginning of 2020 in Indonesia continued to increase (Benvenuto et al. 2020); in the circumstances that occurred at this time, there have been many efforts that the community can make to adapt and make lifestyle changes in the ongoing pandemic conditions (Mailizar et al. 2020). The pandemic has given new regulations in many countries, including Indonesia; school-from-home regulations have been implemented starting the first week of March 2020. The learning and teaching process is conducted online to avoid the broader spread of the Covid-19 virus (Mailizar et al., 2020). Such conditions make educators have to be creative in providing learning and teaching systems so that they can be accepted more easily and well by students (Alhammad, Software, and 2018 2018), especially for elementary school students. Teachers have used various online applications to help make it easier for teachers to teach and students to learn from home (Sari et al., 2020). Such as the google classroom application, which teachers use to make it easier to provide teaching materials, and assignments and manage classes online to make it easier for students to access them(Iftakhar 2016). There is a previous case study that teachers evaluate learning with students using platforms such as Quizziz (Bidarra, Figueiredo, and Natálio 2015) and Kahoot (Iwamoto et al. 2017), and Proprofs (Hanbidge, Sanderson, and Tin 2016). However, in previous studies, evaluations were carried out by teachers to find out how the progress, development, and success of students in following the learning process that had been determined had not been standardized, and most teachers did not know how the evaluation was

and seemed dull (Cheong, Filippou, and Cheong 2014). Previous research has recognized that the types of students today use more electronic-based games (Greitemeyer and Osswald 2010), the average time for elementary school students (Deterding et al. 2011). This makes it easier for teachers to evaluate learning using a gamified scenario-based evaluation platform and where students can be more interested in evaluation software when they can actively solve problems such as experiments in making decisions, solving problems, and ideas. to be able to think analytically, systematically and can be found (Eble and Hu 2019). Overall, gamification positively affects the development of students' knowledge (Fanani et al. n.d.; Fitz-Walter, Tjondronegoro, and Wyeth 2012).

Online learning provides inter-school learning, starting from the condition of the material provided (Greitemeyer and Osswald 2010), daily student attendance (Guay and Bureau 2018), and student study time per day (Hanbidge, Sanderson, and Tin 2016). Therefore, it is a forum that is agreed upon to be used as a reference by schools. In this case, in STEM learning, STEM learning is learning that is agreed to be an essential lesson that teaches science, technology, engineering, and mathematics. STEM learning has been used in various countries; the learning process does not refer to existing education but refers to how students can solve a problem (Nguyen et al. 2018), directly proportional to combining online learning evaluations based on STEM learning. Gamified STEM-based evaluation software provides a combination of standard evaluation by not using a specific curriculum but using real-life cases to improve students' cognitive aspects in analyzing and reasoning by adding gamified features to add users in the evaluation process, the most important for elementary school students. Has an urgency that aims to connect the facts about learning and combine it with an online gamification learning evaluation tool based on STEM learning that provides a fun but standardized learning evaluation and provides a good design process by combining creativity and to match what is expected. Needed by elementary school students to make it easier to evaluate learning at this time with the application of the 6D framework. The application of this 6D framework has a good analysis and design process that makes it easier to implement gamification elements on the Software being built (Alhammad, Software, and 2018 2018) to minimize the possibility of errors in the development of gamification software.

The purpose of this study is to build an online learning evaluation application that adds gamification elements to motivate students to learn with gamification software in which there are four fields of science, namely science, technology, engineering, and mathematics for elementary school students.

2. Methods

A good design process melds creativity and structure to match people's needs with technical feasibility and business realities. The same case is also applied to designing good quality gamified Software. This research carried out several stages, as shown in Figure 1. These stages are a method of the 6D framework (figure 1); the first stage is to define business objectives. This stage is the first step when working on this study are shown in Figure 1.

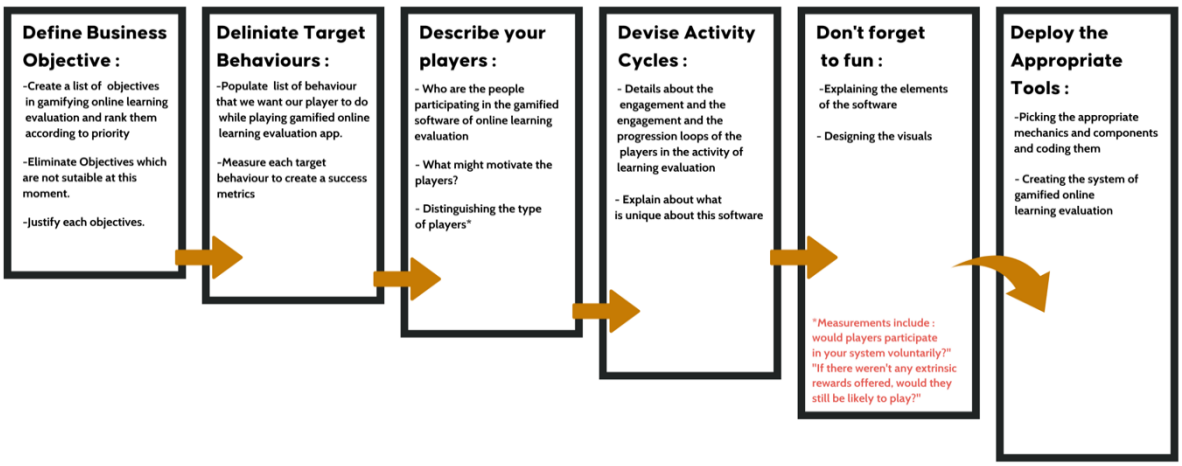

Figure 1. Research methods in research

In this paper, we describe the study of gamification in evaluating stem learning to the implementation stage. Next is the evaluation stage by describing the final results of the performance of each stage and software adjustments

2.1 Define

Our first stage begins by establishing the main objectives of the gamified online learning evaluation software concerning the specific objectives of the applied gamified system. Determining goals has stages; identify goals, create a list of goals, identify rankings based on their importance and adjust each goal to benefit the player.
We aim to motivate players to develop their online learning process by listing the priorities in the learning evaluation gamification we described (in Table 1). We apply the objectives based on the school as a reference.

Table 1. Online Academic Evaluation Objective List

Priority	Objective Name	Measurement	Benefit (Justification)
1.	Improve the results of STEM learning evaluations	Pre-test Vs. Post Test	Students become more motivated and eager to evaluate learning
2	Frequently doing their online evaluation	Frequency of playing the game (compare day by day)	Students keep practicing and have a better understanding of the subject
3	Competition among students	Leaderboards	Increasing the standard of grade in each school

In Table 1, we rank the priority goals of this online learning evaluation gamification by prioritizing each goal, determining the size, and the benefits that will be obtained from each goal.

2.2 Delineate

The learning we use is based on Science, Technology, Engineering, and Mathematics (STEM) as a reference in implementing online learning evaluation applications, where the players are students, and their behavior will be determined by game elements defined through gamified activities paired with problems that occur in the world and problem-based learning. This approach creates an active and cohesive learning system to solve problems (Julià and Antolí, 2019). So, we aim to make the target behavior compatible with the predefined intended use of the Software. We define behavioral targets in Table 2.

Table 2. Target Behaviour of Gamified Online Learning Evaluation Software

No	Behavior	Success Metric	Objective Supported
1	Keep playing to challenge the score	Increase in score	Improve the result of STEM Learning Evaluation
2	Daily visits to the game	Completing the question daily	Frequently play the gamified Software
3	Often do, each subject	Increase the score of each subject	Competition score of each student on the leaderboard

Table 2 describes the three behaviors combined with success metrics and goals that support player behavior.

2.3 Describe

At this point, participants who will achieve the goal are explained by defining who they are, the type of relationship to the game provider, needs, motivations, and grouping the participants into subgroups, trying to produce gamified strategies that apply to several subgroups. We create descriptions with academic context, demographic data, prior knowledge, learning styles, and the tools they access that can be used according to the Software we make. In evaluating

online learning, it is crucial to know the level of prior knowledge and tools that know their use (Gomez-Jaramillo, Moreno-Cadavid, and Zapata-Jaramillo 2018).

Using gamified Software, elementary school students will play an online learning evaluation as participants in the age range of 6-8 years (grades 1 to 3 of elementary school). The age range of 6-8 years is considered the age range in a significant period for learning (Vygotsky 2011) called preschool. However, since there is no preschool test or evaluation, we only use the age range 1 to grade 3. Other studies have also shown that this age range is susceptible to severe interference in learning. Sed learning can motivate students to focus on learning objectives (Tüzün et al. 2009). Both studies confirmed our players' choice to participate in the gamified learning evaluation software.

We gathered as many as 30 students from international private schools. All of us were treated as initial participants. We do a demographic classification based on their gender, class, and experience in the game/online environment, as shown in Figure 2.

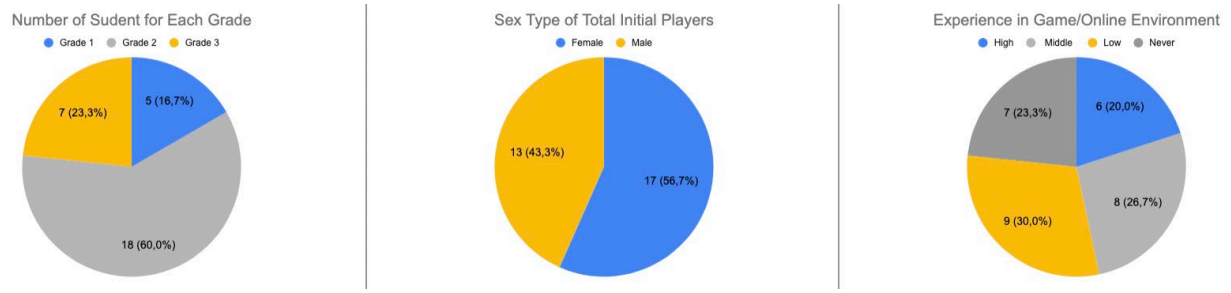

Figure 2. Player's Demography by Grade, Sex Type, and Online Experience

Different players who play this learning evaluation gamified Software have been identified. Early text-based multiplayer online games are the most famous model invented by Richard Bartle in the late 1980s. The model distinguishes four players: achievers, exploits, socializers, and killers. In the implementation of gamified, where we offer two categories of players, achievement, and playing, we define these categories in Table 3.

Table 3. The Characteristics of Two Players

No	Type of Player	Characteristic	Feature Offered
1	Achievers	Relish the rush of leveling up (Chapter up) or earning the point	High Score; Badges for each achievement
2	Explorers	Want to find new content	Reach a certain level (Chapter) an opening op secret level (Chapter)

2.4 Devise

There are two types of cycles to develop: the cycle and the developmental ladder. The first cycle explains at the micro-level, i.e., what players do, why they do it, and what the system does in response. The progression ladder provides a macro perspective on the player's journey. This learning evaluation software applies both. In playing it, players must follow the cycle of the game. They must first choose the lesson to be chosen. After the lesson selection, the player must "fight" the chapter. If each chapter is by the minimum score, it will automatically open the next chapter. The purpose of the scoreboard is the number of scores obtained here to motivate students to be challenged and compete in quizzes so that they do it seriously (Rocha et al. 2015). To change students' experiences as they change at each stage, we defined the Gamification Loop of Online Learning Evaluation, as shown in Figure 3.

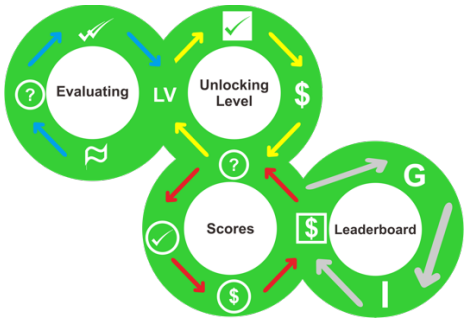

Figure 3. Gamification Loop of Online Learning Evaluation

According to the gamification loop created earlier, we created Table 4 to visualize the experience changing as the player moves from one stage to another.

Table 4 Experience changes at each stage

Stage	Experience Changes
Evaluating	When opening the application for the first time, students are directed to conduct an evaluation. At this stage, students are required to answer the questions provided. If the questions are filled in, students will get evaluation results from the questions that have been answered.
Unlocking level (chapter)	When students get the evaluation results, the subject will be opened, and the level (chapter) is open. After opening the level (chapter), students are asked to work on questions at the level (a chapter that has been opened). At the next level (chapter), the difficulty level will increase.
Scores	In answering each level (chapter), students are asked to answer correctly, and the minimum score that must be obtained at each level (chapter) is +80 to be able to open the next level (chapter).
Leaderboard	The score will be shown on the leaderboard for each completed and unlocked level (chapter). And the total score obtained can be compared with the scores of other players.

2.5 Don't forget to fun

Gamification, one of the reasons gamifications fails is because they focus on using elements without compiling the game (Gomez-Jaramillo, Moreno-Cadavid, and Zapata-Jaramillo 2018). This is important because, intrinsically, the game must bring the fun. If it is considered unpleasant, then the application of game elements is not for the game. So, implementing gamification into this application is very important to increase learning effectiveness. This affects students interacting with the content provided, increasing student motivation, and learning from mistakes (Steinkuehler, Squire, and Barab 2012). So, when students use gamification applications, although application content usually cannot be associated with actual games, students can still experience experiences such as playing games and achieving the expected goals. According to McManus, pleasure is divided into five types, namely: Sociability is characterized by joking, laughing, talking, and entertainment; Contentment is characterized by peaceful, warm, relaxed, loving, and caring; Achievement is characterized by focused, challenged, accomplished, absorbed, and engrossed, some sense of flow; Sensual is characterized by lust, intimacy, and romance; and Ecstatic is characterized by crazy, passionate, and energetic. So, for this application, for elementary school students with a grade range of 1-3, the type of fun we use is based on the type of achievement that has been focused, challenged, and achieved. The application fun factor into two factors, as shown in Table 5 below.

Table 5. Fun factors of the Online Learning Evaluation Software

Factors	How to get fun	Effects
Leaderboard	- Answering a question correctly (Score +50) - Answering questions with wrong answers (+0)	Motivate; Compete; Interest; Challange
Game Levels (Chapter)	- - Answer every question in the chapter with a minimum score of +80 - Complete each lesson	Satisfaction. Accomplished. Engaging. Collaboration;

In application, the leThen affect motivation, post-test performance, and competition process challenges (Cagiltay, Ozcelik, and Ozcelik 2015). Furthermore, the leaderboard system can increase students' interest, enjoyment, excitement, and involvement. There are four levels (chapters) in this application. Each number at the level (chapter) has a higher difficulty level, so it challenges students to open the level (Chapter) and complete the evaluation of each subject.

2.6 Deploy

At this last stage, implementing the ideas that have been described in the previous 6D stages into a more detailed and visible product form. At this stage, also develop a rapid prototype. We completed the gamification of this learning evaluation to support the combination of games and learning so that children are motivated to learn. Due to the development of online class gamification, users can use the application effectively and efficiently. (Aini et al. 2018).

2.6.1 Software Implementation

We can complete the gamification of this learning evaluation to improve children's enthusiasm and ability to learn wherever and whenever. In its development from time to time, elementary school children are good at using electronic media tools such as PCs and cellphones. To give children an interest in learning online quizzes, gamification is used, which is a concept with a game-like mechanism. The trial implementation can be used to evaluate the Software for the results at this stage. We develop gamification software through an Android-based application and build it with the Chipmunk version of Android Studio 2.1. In the process of making this application, we provide software development. All our data is stored on cloud-based servers. Using internet connection applications is very important because it synchronizes with the server so that data can be stored. This gamification evaluation application makes it easier to understand and work on questions because it uses pictures related to these questions so that students who work do not feel bored. We apply this characteristic learning material to the learning model, challenge, satisfaction, and dependence by adding game elements, namely scores and leaderboards, to motivate students to study harder and work on every question in the application. Lastly, advanced user and game testing after the development cycle is the recommended practice to evaluate and optimize the designed gamification, ensuring its effectiveness and success (Morschheuser et al. 2018).

2.6.2 Welcome Screen and Evaluation Screen

When the user first opens the application after registering or login in, the user will be shown a welcome layer. In this initial screen, the user will be given the option to evaluate, as shown in Figure 4 (Left Image)

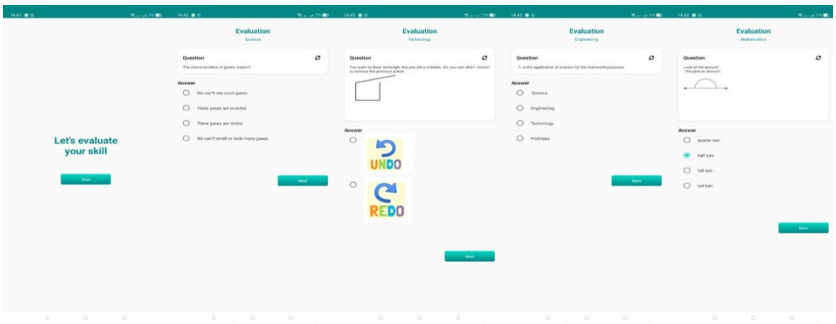

Figure 4. Welcome Screen and Evaluation Screen

In the evaluation menu, this is indicated for the pre-test. On this page, the user enters the evaluation search layer and is given four questions in each subject with a total of 4 problems that will be used in this application: Mathematics, Science, Technology, and Engineering, to open the menu page. The welcome screen section also needs to be considered because it is feared that it will not be by educational goals that apply the concept of gamification games to the material to be studied (TICom and 2016 n.d.). The influence of users to increase interest in an application can be seen in the initial welcome display, so even the initial display must be by the specific principles of gamification of learning strategies.

2.6.3 Result Screen

After the evaluation is complete, the user will be directed to see from the evaluation to the results screen, which can be seen in Figure 5

Figure 5. Result Screen

On this page, users can see their abilities in each subject. The statistics displayed are in the form of bars and percentages to measure their ability through these statistics. The level of each topic will be determined here. If the correct answer from the user in answering the question in one lesson is more than 80 points, then level (chapter) 2 will be unlocked. Furthermore, if it is open (the higher the level/chapter, the more complex the problem will be. After observing, the user can go ahead and enter the screen menu. This result screen displays the results of the quiz that has been done by the user, which can give the user performance, and by demonstrating the results scree,n This also means that users can focus on increasing their overall score again (Baldauf, Brandner, and Wimmer 2017).

2.6.4 Subject Screen

On the subject screen, the user can select which subject to play. Then the user will be directed to the level screen. Figure 5 shows a screenshot of the subject and level (chapter).

Figure 6. Subject Screen

For the right Image in Figure 6, it is a level screen (chapter). There are four levels available. By default, the game will start at the level (chapter), but players can pass the level according to already getting at least 80 points in each level (chapter). If the user is at level (chapter) 1 and wants to level up, the user must do all the questions at that level and get a minimum score of 80 to continue to the next level. The status given in the gamification is used as a reference to the level of the game or games that the player must take. For example, at level 1, it is relatively easy, then at the next level, the player gets ready for a higher level of difficulty. This condition makes it easier for players to judge their abilities. The player's story will also determine how far the game will end and measure the ability to what extent.

2.4.5 Subject Question Screen

The user will be asked questions in the subject question screen according to the selected subject, level, and chapter. Each successfully answered question will give you ten score points. Furthermore, the user is required to achieve a minimum score of 80; if it is less, the player will feel challenged and repeat the answer until it is correct. If the question is reloaded, it will always appear in a different order of questions. The subject question screen has question levels from most straightforward to medium to most complex. From these questions, players get a challenge to do the quiz (Zinnen and Godehardt 2018). Figure 7 shows the subject question screen.

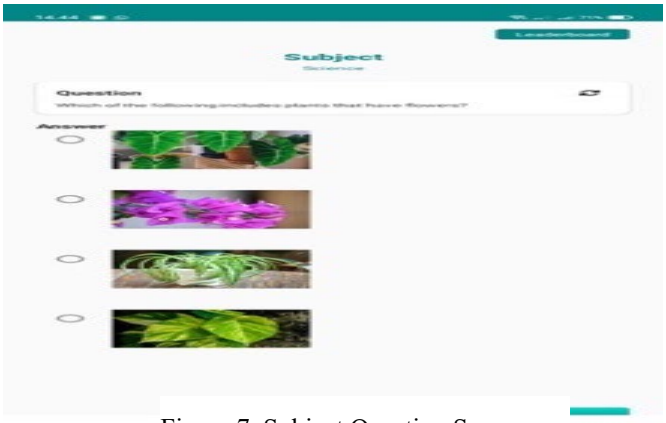

Figure 7. Subject Question Screen

2.6.5 Leaderboard Screen

Leaderboard screen where users can see the total score of others in individual scope so that users feel challenged to collect multiple scores. Leaderboards provide information about players' improvement and abilities with other players. Leaderboards are added to encourage players to try to improve their performance so as not to lag behind other players (Fitz-Walter, Tjondronegoro, and Wyeth 2012), as we can see in Figure 8

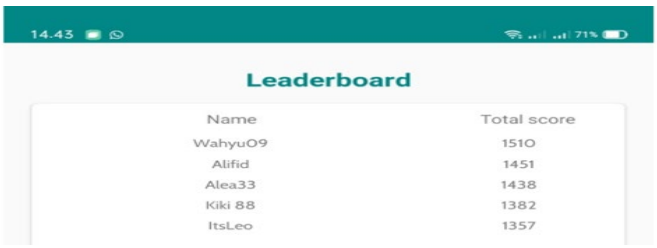

Figure 8. Leaderboard Screen

3. Results and Discussion

At this stage, we will explain the results of this study. The calculations are carried out on international school students aged 6-8 (grades 1 to 3 of elementary school) who play an online learning evaluation application. All parents of respondents in this study were asked to agree to give their children more screen time in addition to their usual school activities from home. This evaluation application is distributed in APK form to teachers or children's parents. We

collected 30 students to make respondents with their status as our initial participants. This evaluation period lasts 7 days. We monitor their activity in the Software by evaluating based on the pre-test and post-test results and monitoring activity using the activity log.

3.1 Pre-test Vs. Post-test Results

Assessing elementary school students on gamified Software is not an easy task to undertake. However, in previous studies, direct research involvement was carried out with students (Stålberg et al. 2016) because, during the current pandemic situation, we have limitations to meeting students directly, so we create activity logs in the Software to record the scores obtained. Below can be seen in Table 6, Pre-test vs. Top 5 post-test leaders visualizing our top players in the evaluation period.

Table 6 Pre-Test Vs. Post-Test Results for Top-5 Leaderboard

Top Rank	Username	Score	STEM – Level 1 (Chapter)				STEM – Level 2 (Chapter)				STEM- Level 3 (Chapter)				STEM- Level 4 (Chapter)				Total
	(ID)		S	T	E	M	S	T	E	M	S	T	E	M	S	T	E	M	
1	Wahyu09 (Grade 2)	Pre	80	80	80	80	80	100	60	60	100	60	60	80	80	60	60	60	74
		Post	100	100	90	100	90	100	100	90	90	100	100	100	90	90	100	90	96
2	Alifid (Grade 3)	Pre	80	80	80	80	80	60	80	60	80	80	60	60	70	60	60	60	71
		Post	100	100	90	100	80	100	90	90	90	90	80	90	80	80	90	100	91
3	Alea33 (Grade 1)	Pre	80	80	80	80	60	80	60	60	100	80	60	60	60	60	60	60	70
		Post	90	100	90	90	90	90	90	80	100	90	90	80	90	90	80	90	90
4	Kiki88 (Grade 2)	Pre	80	80	60	60	60	60	60	60	60	60	60	60	60	60	60	60	63
		Post	92	95	89	92	80	90	80	90	90	80	90	80	80	80	80	80	86
5	ItsLeo (Grade 3)	Pre	60	60	60	60	60	40	80	60	60	60	40	40	60	60	60	60	58
		Post	90	90	80	90	80	90	80	80	90	80	80	80	80	80	80	80	83

It can be seen in the table above that each user has shown a significant increase in their overall knowledge, based on subjects and levels (chapters). And this also happened to 30 other students who took part in this study, with their accumulated assessments shown in Table 7.

Table 7 Average Improvements in Learning Evaluation of Top-5 Leaderboard and All Users

	Average improvements on-			
	STEM Level 1 (Chapter)	STEM Level 2 (Chapter)	STEM Level 3 (Chapter)	STEM Level 4 (Chapter)
Top-5 leaderboards	1,27 x	1,34 x	1,36 x	1,39 x
The reset (30 Students)	1,20 x	1.27 x	1. 25 x	1.22 x

Of all the subjects tested, students showed increased knowledge in evaluating STEM-based learning. We saw a higher increase in the assessment at level 2 and a decrease in the 30 students' reset results. This is understandable because most of the users who participate in the game are from class 1 and class 2. Therefore, it is easier for them to participate with level (chapter) 2 than level (chapter) 3 or level (chapter) 4.

3.2 Activity Log: Frequency of Playing

Based on the demographics of our players, we recorded their first 7 days of using this learning evaluation application, as shown in Table 8. This number shows how many times they accessed this game in one day. These experiments were piloted separately, as one user had different game start times, but all were measured based on their daily activity.

Table 8 Top-5 Daily Frequency of Play

Top	Username	Total Daily Frequency of Play (Based on Login Activities)	AVG

Rank	(1D)	Day 1-2	Day 3-4	Day 5-6	Day 7	Freq
1	Febri_	10	6	10	8	4,9
2	ItsLeo	12	8	7	3	4,3
3	Wahyu09	10	6	7	6	4,1
4	Alifid	9	7	6	5	3,9
5	Bobs32	9	8	5	4	3,7

The results above show that the top-5 leaderboard shows that these players not only use the application once or twice a day but regularly play more than twice a day. This condition results in 3 of the five highest scores having a playing leveling and are ranked as the five best in the frequency of playing this application. We have proven other research that shows that more daily participation in gamified Software will increase the knowledge of most users (Buckley and Doyle 2016). An excellent gamified software design will most users' knowledge most users (Sardi, Idri, and Fernández-Alemán 2017).

4. Conclusion

We researched the effect of gamification on students' evaluation experience, which ultimately aimed to increase their knowledge, particularly in science, technology, engineering, and mathematics. We build gamified Software by carefully assessing what features should be included in the game to increase their motivation to evaluate learning, keep practicing achieving a better understanding of a subject, and raise the standard of grades in each school. The three objectives are broken down into features and measured quantitatively during the implementation phase. The results show that by adding gamification to the Software, we can achieve all the goals and increase user knowledge. The target audience is elementary school children who enjoy fun, motivation, and stimulation while doing their learning activities. The increase in knowledge individually and groups was quite significant, with an average of more than 20% and 13%, respectively. Lastly, choosing a suitable method for creating gamified Software. We chose the 6D framework developed by Werbach and Hunter, which carefully describes the stages and variables to consider in creating gamified Software.

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