Improving Knowledge of COVID-19 for Elementary School Students using Gamified Software

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Abstract

Gamification focuses on applying game mechanics to non-gaming contexts for audience participation and incorporates little fun from routine activities other than generating motivational and perceptual benefits. Businesses, schools, universities, and many other types of organizations have harnessed the potential of gamification. Digital health services also take advantage of emerging trends such as remote monitoring of the elderly during the COVID-19 pandemic. As we read all this information, nothing is made especially for kids. This paper aims to apply gamification in COVID-19 learning and measure the increase in children's knowledge, especially from 6 to 8 years. We performed two measurements; The first is an internal context measurement to test whether the system follows the original design or not. The second is on students. Thirty-five students at several schools participated in the implementation and were surveyed using their automated activity logs and then conducted a seven-day monitoring survey. The results showed a significant increase in the total increase in the average score from the first experiment compared to the best experiment, namely 1.26 times in the corona jump, 2.00 times in the corona quiz, and 1.10 times in the corona labyrinth. On the other hand, we found a 28.57% decrease (10 of 35 children) in quitting the game. This condition proves that children need a lot of scenarios and content to enjoy the gamification process in the long term to achieve all abilities and need to take advantage of game mechanics skills and psychological effects.

Keywords
Gamification, COVID-19, Early Education, 6D Framework

1. Introduction
The COVID-19 pandemic has limited all activities worldwide, and the coronavirus's spread rate has rapidly increased (Benvenuto et al. 2020). It affects all areas of life, one of which is the field of education which is the focus of current research (Ariessanti et al., 2020). Nadiem Makarim, as a Minister of Culture and Education in Indonesia, conveyed to teaching staff, both teachers and lecturers, that teaching and learning activities can be done at home and utilize existing technology (Ariessanti et al. 2020). Using technology to help the learning process is Google Classroom and Microsoft Teams to help collect student assignments, class management, and communication between students and teachers (Shampa 2016). Technology also gives students much access to information and knowledge sharing, but it requires teachers to work on finding ways to increase student motivation and engagement (Shampa 2016).

Teachers must be more innovative and more creative in carrying out learning, especially for students who are in elementary school, because it is considered the best period for children to learn their potential (Wu et al. 2019). Elementary school students are generation Z, or net generation, with different characteristics from the previous

generation. Learning innovation for Generation Z is very much needed, considering the characteristics of those who tend to have active, sequential, sensory, and visual learning styles (Cheng 2014). Physical, moral, intellectual, social, and emotional development can be fully achieved by involving children in game-based activities. Game-based learning can help children-especially school-age children improve their learning abilities (Petrovska, Sivevska, and Cackov 2013).

Educational games effectively improve linguistics and logic (Zaranis, Kalogiannakis, and Papadakis 2013)(Vitoria et al. 2020) and motivate children to learn new skills. Game-based learning can keep players focused on the game, meaning that students will also pay attention to the lesson (Nachiappan and Rahman 2014). Game-based learning requires the active participation of the players to experiment in making decisions and solving problems, stimulating analytical thinking, synthesis, and evaluation (Akl et al. 2013). Previous research has been done to promote health and the dangers of obesity for humans (Wen 2017).

The material that must be studied for elementary school students is the coronavirus. The novel coronavirus (COVID-19) shows potential outbreaks in settings and across borders following human mobility patterns (Mizumoto, Kagaya, and Chowell 2020). All countries have implemented lockdowns to stop this pandemic. Previous researchers have used computer/technology assistance in case studies of covid-19 by mapping the disease (Nachiappan and Rahman 2014),(Akl et al. 2013), predicting the rate of spread (Wang et al. 2020), and diagnosing the disease using x-ray (Ucar and Korkmaz 2020),(Ozturk et al. 2020). However, after reading all the information, there is still a lack of information about the coronavirus, specifically for children. Primary school students need to be well informed about this virus, as it has affected their lives, including their education (NUS Saw Swee Hock School of Public Health 2020). This situation is also confirmed by the findings of the covid-19 pandemic that attacks all age groups, including young children (Xing et al. 2020). Covid-19 is a broad topic to study at the elementary school level and is a challenge and requires innovation or an exciting learning style to deliver the material received with high enthusiasm and can motivate the spirit of learning and not get bored quickly. For learning to be readily accepted by elementary school students, they need something interesting to keep the spirit up, so gamification is offered (Swacha, Queiros, and Paiva 2019) to teach and create awareness among these students on a sensitive but crucial topic. UNICEF recommends learning actions for elementary school students, namely, teaching practices when coughing and sneezing, washing hands, recognizing symptoms, and keeping a distance (UNISEF 2020).

The concept of gamification can be implemented into learning media. Gamification has attracted the interest of educators, who have recently explored its potential to enhance student learning (Koivisto and Hamari 2019)(Majuri, Koivisto, and Hamari 2018)(Dichev and Dicheva 2017). Gamification is considered effective in learning and quite promising, with variables up to positive results(Koivisto and Hamari 2019),(Majuri, Koivisto, and Hamari 2018), (Caponetto, Earp, and Ott 2014), (Osatuyi, Osatuyi, and De La Rosa 2018). Previous research has focused on learning about the dangers of COVID-19 using gamification, but it only focuses on one element of gamification, namely the learning context. Even though there are still seven more elements to apply the concept of gamification (Ariessanti et al. 2020) correctly, applying the 6D framework can make implementing the eight gamification elements easier and minimize the risk of errors in making gamification designs (Matsubara and Da Silva 2017), (Rocha et al., 2015).

Therefore, our first step towards providing COVID-19 education to lower primary schools through game-based software is to design games that appeal to them, and research has also been carried out on increasing children's knowledge and practicing problem-solving in a game (Hung et al. 2014). This research aims to develop, implement, and evaluate the COVID-19 educational game, which is one of the strategies to teach health education, especially regarding COVID-19, to students in an innovative new way by applying the 6D framework.

2. Methods

Information systems designers have increasingly used engagement techniques to enhance user experience and should always be considered in user-centered studies (Zarwono and Hidayanto 2020). We design our COVID-19 gamification system using the 6D framework because, according to Werbach, gamification software is best implemented with six steps (Werbach, Kevin & Hunter 2015).

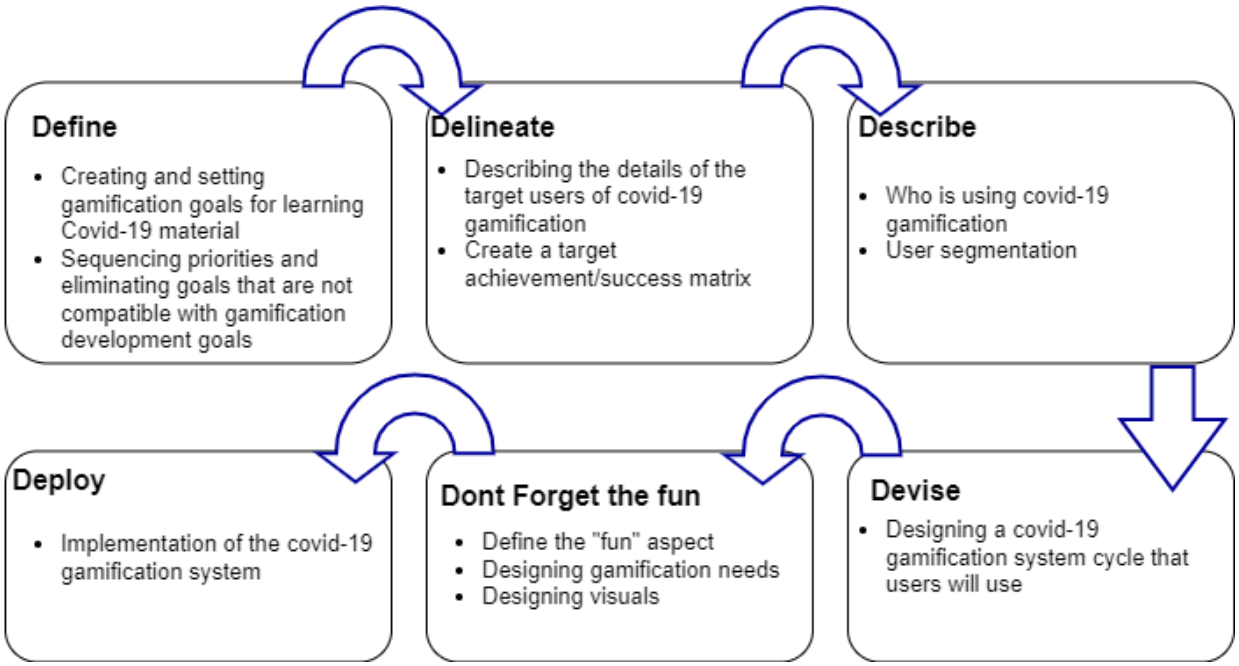

Figure 1. 6D Framework of Learning COVID-19 Gamified Software

In this paper, we describe a study of this COVID-19 gamification for young children until the implementation stage, while we discuss the results through evaluation and monitoring stages. (Figure 1)

2.1 Define

We started by defining the purpose of our gamified software for COVID-19. To cover this primary objective, we identify objectives, create a list of goals, rank them according to their importance, and justify each aim to benefit players. These steps are an essential foundation, and we will examine them further and compare them with the initial objective statement (Fink and Pinchovski 2020).

Our main goal is to explain COVID-19 to students aged 6-8. Next, we want to convey their interest and trigger them to know more about COVID-19 in a fun way without compromising the critical situation. In conclusion, fun learning is the primary goal of our gamified software. Then we write down (in Table 1) a list of objectives according to their priority rank. We use the World Health Organization (WHO) official press conference, a handbook on coronavirus, and a textbook guide on COVID-19 as references in listing all the objectives.

Table 1. List of Gamified Software Objectives (by rank)

Priority	Objective
Rank-1	COVID-19 definitions
Rank-2	COVID-19 preventive actions
Rank-3	COVID-19 symptoms
Rank-4	Identify viruses
Rank-5	Identify immune booster
Rank-6	COVID-19 contagion visualization
Rank-7	COVID-19 social distancing
Rank-8	COVID-19 spreading visualization

We chose COVID-19 as our theme because this virus has caused a pandemic worldwide and attacked all group's ages, including young children (Xing et al. 2020). They are prone to catching and carrying the virus. Hence, they need to be educated concerning the ramification of it. The massive issue for young children needs to be packaged in a certain

way to be highly eager to learn (Chow et al. 2020). COVID-19, like health or virologic topic, is a massive subject for young children; hence, teaching it requires a gamified approach.

2.2 Delineate

The players are elementary school students, and the behavior that will be affected by the game elements must be defined through gamified activities. For example, to increase team engagement, the goal behavior is to increase participation in the development of each team member and their roles (Gomez-Jaramillo, Moreno-Cadavid, and Zapata-Jaramillo 2018).

The behavioral targets to be achieved must be specific and concrete and must be by the achievement of the gamification system goals that have been previously determined, even though this is done indirectly. Expected behavioral targets for the application of gamification can be seen in Table 2.

Table 2. Target User Behavior

No	Expected Behavior Target
1	Keep playing to challenge the score
2	Students are motivated to complete every challenge that exists
3	Elementary school students compete with each other to be ranked top on the leaderboard
4	Students can collect every point there is

2.3 Describe

User analysis was defined to define the user, segment, and identify their needs, motivations, and goals, gamified software to achieve the right user, use the right content, and serve the proper purpose (Oberdörfer and Latoschik 2019). This game targeted students in the age range of 6-8 years (early primary students). We have identified factors from the user's perspective: feel challenged, accomplish learning purpose, repeat play, and use the app daily.

We gathered participants as many as 35 mixed students from public schools, local private schools, and international schools. All were treated as our initial participants. We classify their demography of sex type and grade, as depicted in Figure 2.

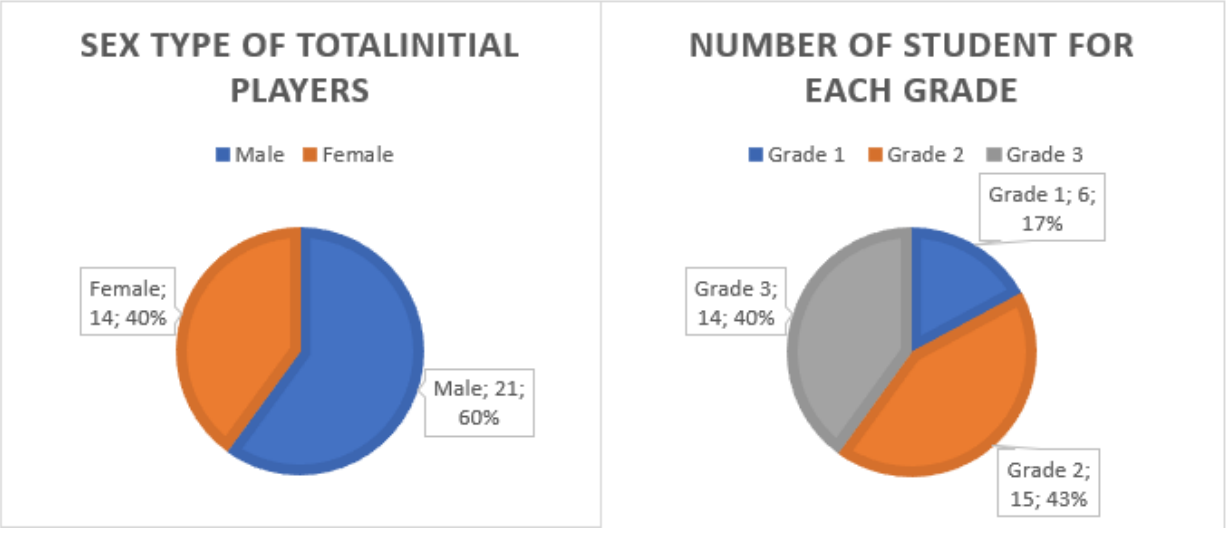

Figure 2. Players' Demography by Sex Type and Grade

Various players can be identified, as can those who play this gamified software. The best-known model was invented in the late 1980s by game researcher Richard Bartle, who studied early text-based multiplayer online games. The

model distinguished four player types: achievers, explorers, socializers, and killers. However, implementing this game only takes two types of player elements, namely achievers and explorers. Good, gamified software always has something to offer for each category, as defined in Table 3.

Table 3. Target Behavior Target Behavior of Gamified Learning Covid-19

Type of Player	Characteristic	Feature Offered
Achievers	relish the rush of leveling up or earning a badge	High score; badges for each achievement
Explorers	want to find new content	Reach a certain level and open up a secret level

2.4 Device

The model proposes two types of cycles: motivational and developmental cycles. The former provides a micro perspective, explaining what players should do, why they should do it, and the systems in place to respond to it. Motivation causes participants to act, which results in instant feedback that seeks to generate greater motivation in the player to take a new action. Problems arise when this cycle becomes repetitive because the first day's motivation will not be the same after a while. It is at this point that a progress cycle is required. This second cycle generates a macro perspective during the player's journey through the gamified world.

Figure 3. Corona Fight Game Loop

With this covid-19 learning software, they can choose what gameplay to play. First, this software presents three gameplays at once "corona jump, corona labyrinth, and corona quiz. (Figure 3) Main game elements such as score, rewards, leaderboards, and levels, among other features, are commonly included and used to gamify a system. Awards appear every time the user achieves goals supported by the scoring system. Subsequently, to motivate challenge and competition, the scoring system and achievements history will be found on a scoreboard (Rocha et al., 2015)(Alhammad and Moreno, 2018).

2.5 Don't Forget the Fun

Many gamification implementations fail because they focus on using elements without structuring the game. This is important because the game brings fun; if it is not fun, it cannot be considered to apply the game in a serious context. The application of gamification should result in participants who are motivated to play, even without the extrinsic obligation of being part of a work team in the software development process, but who wish to improve their process using the game of their own free will. According to Nicole Lazzaro, there are at least four dimensions regarding the fun aspect: hard fun, easy fun, altered states, and the people factors. The fun dimension analysis can be seen in Table 4.

Table 4. Fun Dimensional Analysis

Fun Dimension	Activities
Hard Fun	Players can play different gameplay and try to be the first rank.
Easy Fun	Players can freely explore the gameplay provided and can control the player at will.
Altered states	Players are presented with different gameplay at each stage.
The people factor	Players can view leaderboards and profiles of other players.

2.6 Deploy

The last stage in making a gamification system with the 6D framework is to implement the previously made steps into a tool or tool that will help form the gamification system. We can complete this Covid-19 learning gamification to increase the enthusiasm and ability of children to learn anywhere and anytime. We develop gamification software through Godot Engine with version 3.2.3. In this process or framework, we provide software development. All our data is stored on cloud-based servers. Internet connection is essential because it synchronizes with the server so that data can be stored. Learning materials are implemented by adding game elements such as scores and leaderboards to motivate students to be more active in doing quizzes in this game (Alhammad and Moreno 2018).

3. Results and Discussion

To develop and implement a gamification approach to the socialization of the infamous COVID-19 for primary students. We want to make a rapid development to research the trending topic while maintaining good, gamified software quality. We managed to make the game in 39 days and did several tests and measurements. We conduct two evaluations. The first was an internal test; to compare the objectives set at the beginning with the implementation result. The second test was for the students to measure their improvement of knowledge about COVID-19.

3.1 Evaluation of Context

The system's context needs to be evaluated, whether it stays consistent throughout the implementation and is there as a final product (Petter, Delone, and Mclean 2012). In Corona Fight, the context given or presented to the user is to be able to "identify immune boosts" and "identify the virus or infected people" These two contexts have been fulfilled, as depicted in Figure 4 below.

Figure 4. Corona Jump Context

We have an opening screen that tells the story behind the adventure. The user, playing as a kid character, must travel from his first place to his house while passing through obstacles of kids infected with COVID-19, viruses, germs, and

dirt. We gamified the introduction of the immune booster to increase the energy level so the child would not get infected by COVID-19. We also implement the introduction of viruses, germs, and specks of dirt. Energy gained from a 'carrot' will increase by 10% of power, while 'apple,' 'milk,' and 'vitamin' will earn 20%, 25%, and 30%, respectively. On the negative side, a hit (direct interaction) with an infected kid will reduce the energy to 70%, while hitting the 'virus,' 'germ,' and 'dirt' will reduce 40%, 25%, and 10% as well.

Furthermore, in the context of measuring users' understanding of social distancing, the spread of COVID-19, and its contagion effect, we use the labyrinth game as a visualization to make it easier for users to understand what to avoid when they are exposed when a pandemic occurs as seen in Figure 5.

Figure 5. Corona Labyrinth Context

The visualization of the spread of the COVID-19 virus is found inside the Labyrinth. The infection can spread through droplets in the object box or swarming with people infected with the COVID-19 virus. The contagion of COVID-19 is through contact with an infected person, and the virus accidentally enters our bodies or through droplets from infected people or things. As we can see in Figure 5, there are two pictures depicted. The right side represented the process of a user when it got infected by people and the box. The application of social distancing was also introduced in this game. Users cannot get infected with the virus if the infected people do not come near them or they do not touch the box.

Finally, in the context of learning evaluation, using the Corona quiz game, users can measure and evaluate their learning about COVID-19 regarding definitions, preventive actions, and symptoms, as seen in Figure 6.

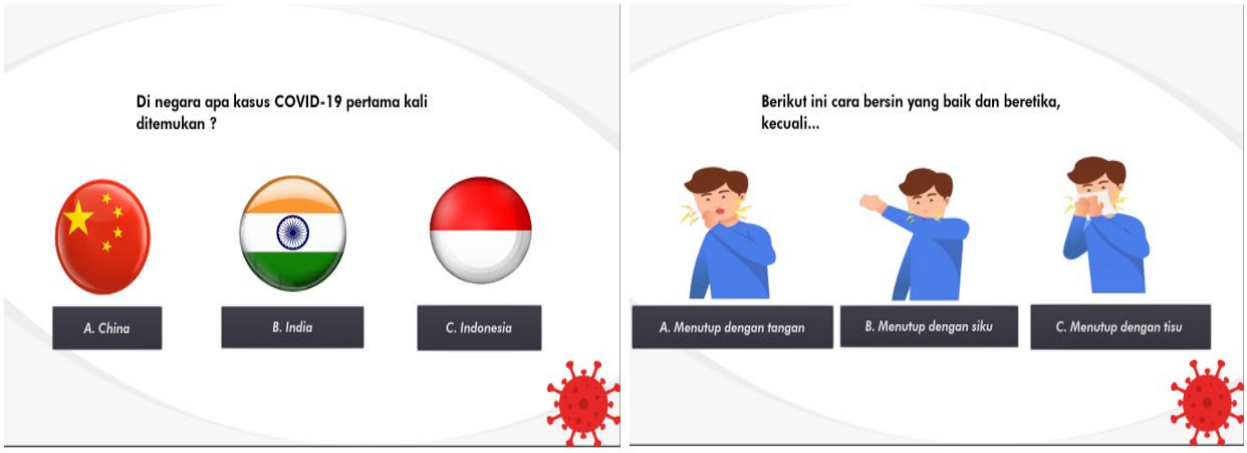

Figure 6 Corona Quiz Context

3.2 7-day After Monitoring: Activity Log

Evaluating gamified software used by young 6-8 years old was quite challenging. While previous research was conducted through direct engagements to assess the design (Stålberg et al. 2016), results estimations, and teachers (Bers, González-González, and Armas-Torres 2019), none were done on young children of 6-8 years old to measure the improvement of knowledge. Therefore, we conducted a common pre-test vs. post-test approach to capture it. Unfortunately, due to COVID-19, we have limited or no interaction with the users. Hence, we created activity logs inside the software to record the score obtained, the number of correct answers, and the finish time when playing the corona jump, corona quiz, and corona labyrinth.

Firstly, we introduce the game to three primary teachers and one preschool teacher. Then we set a kick-off meeting to plan the experiment. The teachers contacted the parents and explained the plan and the game scenarios. We determine several teachers' requirements before reaching out to the parents. We require children to be exposed to/introduced to the online game before. Parents must monitor and assist their children during game time, especially the four and five-year-old children who still cannot read fluently. These requirements and limitations are essential to maintaining the study's quality. Initially, we had 22 parents who voluntarily consented to the operations, and then it was increased to 37 parents with the parents' help in promoting the experiment to their friends. Two parents withdrew their participation because the kids did not want to play the game. We conducted a 7-day monitoring scheme of 35 students in the age range of 6-8 years who play the game "Corona Fight." We recorded their first eight attempts, only used the finished score and time, and omitted the unfinished ones. We can see all the activity logs from Table 5 until Table 7 (top-5 users).

Table 5. Top-5 Activity Log of Corona Jump

No	Username	Corona Jump attempt no-								Best Score
		1	2	3	4	5	6	7	8	
1	Rakka	240	230	235	250	280	385	365	370	385
2	Adam	230	220	250	285	310	345	310	330	345
3	Deboo	210	230	235	265	295	285	320	310	320
4	T4uf4n	210	230	240	250	290	305	300	300	305
5	Lizzie	220	245	230	250	250	300	290	295	295

Table 6. Top-5 Activity Log of Corona Labyrinth

No	Username	Corona Labyrinth attempts no-								Best Time
		1 **(m:ss)**	2 **(m:ss)**	3 **(m:ss)**	4 **(m:ss)**	5 **(m:ss)**	6 **(m:ss)**	7 **(m:ss)**	8 **(m:ss)**	
1	Shaquille	1:55	1:47	1:50	1:44	1:50	1:40	1:42	1:42	1:40
2	Lizzie	2:04	2:05	2:08	2:00	2:02	1:45	1:59	1:56	1:45
3	Azka	2:02	1:57	1:58	1:55	1:52	1:49	1:49	1:50	1:49
4	Marco	2:08	1:53	2:02	2:15	2:12	2:09	2:04	2:00	1:53
5	Martha13	2:10	2:00	2:06	1:55	1:59	2:02	2:04	1:59	1:55

Table 7. Top-5 Activity Log of Corona Quiz

No	Username	Corona Quiz attempt no-								Best Score
		1	2	3	4	5	6	7	8	
1	Reeya	50	70	70	70	80	100	100	100	100
2	Adam	50	70	60	60	100	90	90	90	100
3	ThasQ	30	60	70	80	90	90	90	90	90
4	Luna	40	50	50	70	60	60	90	70	90
5	Galang	40	50	60	60	80	80	80	70	80

Taking those results from 3 games and comparing the first attempt with the last and the best one, we can see significant improvements for everyone. For the top-5 data, we can see that in the corona jump game, the increase reached 1.54 times by comparing the first and last trials and 1.60 times when comparing the first and best trials for the first-ranked players. The increase was as high as three times on the corona quiz, comparing the first try with the last or the best try. Finally, for the corona labyrinth, the increase is 1.07 times for comparing the first experiment with the second for rank one, then 1.15 times if we compare the first experiment with the best experiment. We present the average improvement of 35 students playing this game and the top 5 leaderboards in Table 8.

Table 8. Average improvements of top 5 leaderboards and all users

		Average improvements on-		
		Corona jump	Corona labyrinth	Corona quiz
top-5 leaderboards	Vs. Last try	1.44 x	1.09 x	2.06 x
	Vs. Best try	1.48 x	1.14 x	2.25 x
35 students	Vs. Last try	1.21 x	1.04 x	1.85 x
	Vs. Best try	1.26 x	1.10 x	2.00 x

In all aspects, our students showed improvements in the game as well as in their knowledge. Improving the score and time will not be possible if they do not understand the game context. The most significant improvements were made in the quiz game section. It is aligned with our gamification purpose since the game is a straightforward question and answer regarding COVID-19. Our evaluation showed that, on average, there were improvements of at least 1.85 times compared to the first try.

3.3 Limitations

During our 7-day monitoring, we also found that many students did not continue playing the game, as shown in Figure 7.

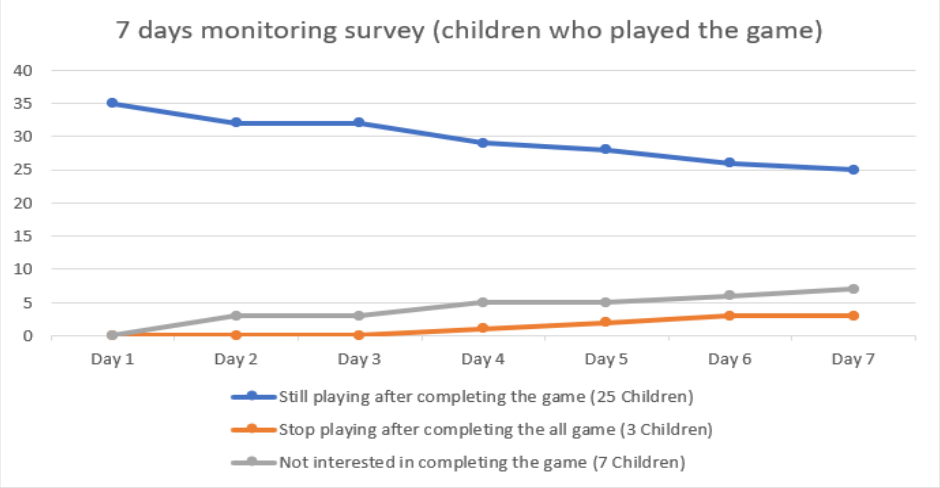

Figure 7. 7-day After Monitoring Chart

We found out that five students stopped playing "Corona Fight" when completing the game's missions. To some extent, it affected players to stop using the game, especially those experienced gamers. They conquered the game the quickest after only a few days and did not play it anymore. According to them, ".... the game Corona Fight was too easy...." It did not attract their attention to repeat the play. Six students who played the game Corona Fight did not want to complete the mission, stating that, "...Corona Fight was not very interesting...". 2 of them said that "I would rather read books and watch tv" when we asked them why they stopped playing the game. To some extent, those statements proved that children need a massive variety of scenarios and content for them to be able to enjoy the gamification process in the long run. Due to our limited development time, we only managed to create limited scenarios for the corona jump and corona labyrinth and can only provide 30 questions for the corona quiz.

4. Conclusion

This study proposed implementing a gamification method to improve users' knowledge of COVID-19. Providing gamified software to our users of 6-8 years old was challenging, especially on how to create interest with, in the end, improving the knowledge. The results indicate that gamification can increase the involvement of participants who interact or engage in the game and encourage those who do not have previous knowledge of COVID-19. We created three types of gamifications on COVID-19 to define COVID-19, describing its behavior, its symptoms, and how to take preventive actions. The improvement recorded was significant, as it can go as high as 2.25 times on average on the game of the corona quiz and as low as 1.04 times on the set of corona labyrinth. The corona jump and corona labyrinth were less improved than the corona quiz since the two games need more motoric involvement than the latter.

Consequent to its rapid development time, this gamification also had its limitation. After conducting A 7-day monitoring survey of 35 users (children who played the game), we found a 28.57% decrease (10 children), leaving only 25 children still playing the game. This condition proves that children need a massive variety of scenarios and content for them to be able to enjoy the gamification process in the long run. For our gamification effort to reach its full potential, it is necessary to exploit the core experience and psychological effects of game mechanics on the children who will play the game.

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