Is Sustainable Online Learning Possible with Gamification?—The Effect of Gamified Online Learning on Student Learning

Sungjin Park and Sangkyun Kim *

Abstract: The use of gamification is garnering attention as a method that promotes sustainable learning during the coronavirus disease 2019 (COVID-19) era. This study investigates the effect that gamified online learning has on student learning and has utilized a gamified online learning program to examine the impact. To determine the program’s effectiveness, a study has been conducted with 140 elementary and middle school students. A previously developed survey instrument was used to measure the results. The study’s findings suggest that gamification in online learning has a positive impact on learner motivation and the understanding of the educational content. Based on the findings, this study proposes that gamification should be used as a sustainable method to achieve the United Nations’ Sustainable Development Goal 4 (SDG 4) of ensuring “quality education”.

Keywords: gamification; sustainable online learning; SDGs; gamification in education

1. Introduction

The world has been dealing with the impact of the coronavirus disease 2019 (COVID-19) pandemic since the beginning of 2020. Consequently, numerous offline activities, from exercise to dining out, have been controlled or restricted. However, as there is a need to ensure continued education despite the pandemic, new methods of learning have been introduced. The solution so far has been online learning. With online learning, teachers and students do not meet at school for classes. Instead, they interact virtually through computers and smartphones from their own homes.

However, online learning has had certain drawbacks. For example, learners and instructors experienced stress while transitioning from offline to online learning [1]. Additionally, the stress increased due to the increased exposure to digital screens, and the symptoms of stress and anxiety worsened as screen time increased [2].

Consequently, people have been developing teaching methods to mitigate the problems that have arisen due to online learning. Cai and Wang [3] developed a six-step teaching method that focused on the use of academic performance feedback to ensure a smooth online learning experience amidst the COVID-19 pandemic. Sathish et al. [4] found that interactive learning, an element of education that is essential for traditional teaching methods, is also effective for the online teaching methods being used during the COVID-19 era, and they presented the necessity of a method that promotes learning through learner-to-learner interactions. Such interactions have a positive effect on the prosocial behavior of learners, thus, facilitating the creation of a sustainable learning environment [5]. Prosocial behavior refers to a series of social behaviors in which learners form bonds to seek mutual benefit, such as helping other learners or supporting people at risk [5]. Thus, to create a sustainable online learning environment, interactive learning tools should be utilized and learner fatigue must be minimized.

Gamification has begun to attract attention as one of the ways to solve educational problems caused by COVID-19. In this technique, game elements, including badges,
points, leaderboards, virtual currencies, and other game mechanics are used in non-gaming contexts, such as in the fields of business administration, marketing, health care, and education [6]. The application of gamification in education enhances learner motivation and participation and also improves the learner’s attitude [7]. According to Park and Kim [8], gamification is most actively applied in the fields of education and training. Applying gamification to online learning programs encourages knowledge sharing activities by promoting learner-to-learner interactions [9]. Also, gamification is used more than other techniques that also use the principle of the game and has been used in many contexts (Figure 1). For example, according to Park and Kim [8], it has been used in marketing to improve customer loyalty and manage business. In the field of human resource management, it has been effective in reducing costs by improving employees’ professional abilities and attitudes towards work. When applied to our lives, gamification can have a positive impact on time management, cost management, and health care. Furthermore, it has a positive impact by helping to improve social issues, such as providing for those in need and hunger.

Gamification has begun to attract attention as one of the ways to solve educational problems caused by COVID-19. In this technique, game elements, including badges, points, and rewards (Figure 2). Missions encompass the activities that users must perform in the gamified situation. In the educational environment, the mission is a task that the instructor assigns to learners. The learners then work to complete the mission to achieve points after completing multiple missions, learners can then exchange them for various rewards. In this structure, learners can exchange the points that they earned for rewards, such as a pencil, textbook, or handwriting tool that facilitates the learning activity.

This study discusses the possibility of establishing a sustainable learning environment by applying the benefits of gamification to online learning contents. Gamification acts as a medium that connects learners with online learning content [13] while also providing an innovative methodology for feedback-based learning [14]. Therefore, this study aims to prove the causal relationship between online gamified learning content and learners by addressing the following research question (RQ).

RQ: Does online gamified learning content have a positive effect on learners’ motivation to learn?
2. Methods

Science Level Up—Online Learning Gamification for Science Learning

This study attempted to identify a gamified online learning program to conduct an experiment. A program that is accessible by computers and smartphones, and is suitable for use in schools had to be identified. Science Level Up, an online learning platform, met the criteria and was offered free of charge by public institutions in South Korea. Science Level Up offers gamified learning programs for science education for elementary, middle, and high school students (Figures 3 and 4). The platform was suitable for this study as learners were able to access and use it in real time and could access it online while at home or in school. Figure 3 presents a gamification called “Corona Challenge”. Participants who play the corona challenge try to avoid the coronavirus by moving their imaginary characters. As they try to avoid the virus, players can learn about basic preventive measures such as wearing masks, hand washing, and the molecular structure of the corona virus.

Figure 2. The basic structure of gamification [12].

Figure 3. The gamification content “Corona Challenge” on Science Level Up pages.
After signing up on the Science Level Up website, users can accumulate scientific knowledge of their choice by using the available programs. The platform offers various educational resources, including gamified learning programs, simulation games, and educational videos. Users select the content of their choice and earn a science quotient (SQ) after successfully completing the program.

The basic structure of gamification applied to Science Level Up is interpreted as follows. Learners use Science Level Up to gain scientific knowledge. After signing up on the Science Level Up website, they can acquire scientific knowledge by exploring the programs that appeal to them. Science Level Up offers various missions, which include gamified learning programs, simulation games, and educational videos. Learners select the content they want to learn and earn an SQ after successfully completing the program. If learners consistently collect SQ, they are rewarded by advancing to a higher level. The higher level is awarded to the learners as a concept of reward for successfully completing learning activities. In addition, when they achieve a higher level, learners can explore additional learning content on Science Level Up.

As can be seen in Figure 5, a user who successfully completes the learning program A obtains an SQ, which is ranked on the leaderboard. Additionally, Science Level Up manages users according to their classes. This feature makes it convenient for instructors, as they need to manage different classes of learners and facilitate sustainable use of the platform. Instructors can create an instructors-only account and register learners, enabling them to monitor the progress of learners by providing information regarding the programs that have been completed, how many SQs learners have earned, and their level.

Figure 5 presents the leaderboard of a class that has been taught using Science Level Up, for which the teacher creates an online class, and registers the learners. As the registered learners play gamification in the program, their play is recorded and compiled as a leaderboard, as shown in Figure 5. The leaderboards list players in order based upon their ranking, ID, total earned SQ, and level.

To measure the educational effectiveness of the gamified science learning platform, a class using Science Level Up was conducted for eight weeks with South Korean elementary and middle school students. The group included 85 students from grade five and 55 students from the first year of middle school. After the eight-week class, a survey was conducted with the students (Table 1). This study used an elementary–middle school teachers network consisting of 20 to 30 people to form an experimental group. In response to the request for cooperation, one class in the fifth grade of elementary school and one class in the first grade of middle school voluntarily agreed to participate.

This study identified the content of science class composition and learning used to conduct experiments and then applied the contents of Science Level Up to supplement student learning. The participant class of fifth graders in elementary school were learning about volcanic eruption, magnet nature, solar system composition, body structure and
function, and heat conduction. The participant students in the first grade of middle school were learning about space/astronomical, acid–base-neutralization, oxidation, and seismic design. The instructors of these two participant classes selected Science Level Up content related to what the students were learning in each class. The instructors then taught their respective students using the Science Level Up content. This study did not intervene during the course of each science class.

Figure 4. The gamification content “Creatures and Viruses” on Science Level Up pages.

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Figure 5. Player leaderboard on a Science Level Up page.

Table 1. Grade/Gender Distribution of Participants.

| Grade         | Gender (Male) | Gender (Female) |
|---------------|---------------|-----------------|
| Elementary fifth grade | 41            | 44              |
| Middle first grade    | 27            | 28              |

The questionnaire was conducted after the completion of the curriculum, and the students who participated in the class were asked to complete the post-survey. Printed and provided to learners, the questionnaire was conducted anonymously. To ensure privacy and standard protection of personal information, only the grade and gender, which were necessary information for analyzing the results, were recorded and entered.

This study used a pre-existing survey instrument that has been verified and a self-developed instrument to create a survey comprising 35 questionnaire items and seven constructs. The science motivation questionnaire II (SMQ-II) developed by Glynn et al. [15] was used to assess learner motivation. The SMQ-II included five constructs. The first construct was the motivation to learn science. The questionnaire items of this construct attempted to determine the relationship between the learner’s motivation to learn science and the knowledge that they acquired through learning and everyday life. The second construct was self-efficacy. The questionnaire items of this construct aimed to determine the impact that learning with Science Level Up had on the participant’s learning and the level of a participant’s fear regarding their learning results, tests, and evaluations. The third construct was self-determination. The items of this construct pertained to questions regarding how the participant’s decisions during the learning process affected their learning of science while they used Science Level Up. The fourth construct was grade motivation. The purpose of this construct was to measure the participant’s expectations that they would receive a high score on tests after learning science with Science Level Up and their desire to attain a high score. The last construct was career motivation. The questionnaire items of this construct asked participants about the degree to which the knowledge they gained with Science Level Up related to their future careers. Furthermore, as gamification has
the additional effect of helping learners understand educational content by providing an element of fun, the construct of understanding was also included. The questionnaire items of the understanding construct asked participants if they had difficulty in understanding the content that they learned during the eight weeks.

To verify gamification’s effect on learning, the construct “teaching method” was added when the independent variables were being identified. The items of this construct asked participants about the teaching method that was used during the eight weeks. Specifically, the items asked if they enjoyed the new teaching method or they found it boring and if it helped them concentrate in class.

3. Results

This study analyzed the effect that gamified learning programs have on learner motivation. To conduct the analysis, each of the elementary and middle school students’ questionnaire responses were analyzed using the statistical analysis tool IBM SPSS version 1.0.0.1447. The survey instrument’s reliability was verified by Cronbach’s alpha and analysis of the descriptive statistics of skewness and kurtosis, and the tolerance limit of the regression analysis and the criteria of multicollinearity were applied to verify the results of the analysis. According to Kline [16], the data used in regression analysis must have normality, and the skewness value, which is the index that verifies the normality, must not exceed 3, while the kurtosis value must not exceed 10. Furthermore, this study checked the tolerance and variance inflation factors (VIF) to verify the validity and reliability of the regression analysis results. The tolerance value must be greater than 0.1 and the VIF value must be less than 10.

3.1. Analysis of Elementary School Students’ Questionnaire Results

The results of analyzing the elementary school students’ questionnaire responses are as follows. The Cronbach’s alpha value was 0.951, which indicates a very high level of reliability. Table 2 displays the results of the descriptive statistical analysis. In all seven constructs, the skewness value did not exceed 3 and the kurtosis value did not exceed 10.

Table 2. Analysis of descriptive statistics for elementary school survey response.

|                  | N  | Min | Max | Mean | S.D. | Skewness | Kurtosis |
|------------------|----|-----|-----|------|------|----------|----------|
| Motivation       | 85 | 1.40 | 7.00 | 5.49 | 1.06 | −1.00    | 0.26     |
| Self-efficacy    | 85 | 1.00 | 9.00 | 5.09 | 1.53 | 0.00     | 0.26     |
| Self-determination | 85 | 1.00 | 7.00 | 4.92 | 1.32 | −0.71    | 0.26     |
| Career Motivation | 85 | 1.20 | 7.20 | 4.96 | 1.39 | −0.65    | 0.26     |
| Grade Motivation | 85 | 1.00 | 9.00 | 4.80 | 1.84 | −0.20    | 0.26     |
| Understand       | 85 | 2.00 | 9.00 | 5.85 | 1.20 | −0.13    | 0.26     |
| Teaching Method  | 85 | 2.60 | 7.00 | 6.15 | 0.96 | −1.18    | 0.26     |

Table 3 shows the results of analyzing the effect that a teaching method has on the motivation of elementary school students when Science Level Up is used. The tolerance value was greater than 0.1 and the kurtosis value was less than 10 for all the constructs. According to the analysis results, the usage of Science Level Up had a positive impact on motivation, self-efficacy, self-determination, career motivation, grade motivation, and the understanding of learners. The $R^2$ value of the motivation construct had an explanatory power of 0.22, and the results of the ANOVA analysis were determined to be significant at a level of 0.01. The unstandardized coefficient for the motivation construct was found to be $0.52 (t = 4.88, p < 0.01)$. The $R^2$ value of the self-efficacy construct determined that the $R^2$ value had an explanatory power of 0.20, the ANOVA analysis results were found to be significant at a level of 0.01, and the unstandardized coefficient was $0.71 (t = 4.5, p < 0.01)$. The $R^2$ value of the self-determination construct had an explanatory power of 0.18. The results of the ANOVA analysis were found to be significant at a level of 0.01, and the unstandardized coefficient was $0.58 (t = 4.27, p < 0.01)$.
Table 3. The effect of teaching method on learning effect and understanding.

| Model Summary       | ANOVA  | Coefficients | Collinearity Statistics |
|---------------------|--------|--------------|-------------------------|
|                     |         | Unstandardized Coefficients | Standardized Coefficients | T      | Sig. | Collinearity Statistics |
|                     | R      | R^2 | F  | Sig. | Beta | Std. Error | Beta | T   | Sig. | Tolerance | VIF |
| Motivation          | 0.47   | 0.22 | 23.81 | 0.00 | 0.52 | 0.11 | 0.47 | 4.88 | 0.00 | 1.00 | 1.00 |
| Self-efficacy       | 0.44   | 0.20 | 20.28 | 0.00 | 0.71 | 0.16 | 0.44 | 4.50 | 0.00 | 1.00 | 1.00 |
| Self-determination  | 0.43   | 0.18 | 18.25 | 0.00 | 0.58 | 0.14 | 0.42 | 4.27 | 0.00 | 1.00 | 1.00 |
| Career Motivation   | 0.30   | 0.09 | 8.08  | 0.01 | 0.43 | 0.15 | 0.30 | 2.84 | 0.01 | 1.00 | 1.00 |
| Grade Motivation    | 0.29   | 0.08 | 7.31  | 0.01 | 0.55 | 0.20 | 0.28 | 2.70 | 0.01 | 1.00 | 1.00 |
| Understand          | 0.55   | 0.30 | 36.29 | 0.00 | 0.69 | 0.11 | 0.55 | 6.02 | 0.00 | 1.00 | 1.00 |
The results of analyzing the career motivation construct indicated that the construct’s $R^2$ value had an explanatory power of 0.09, and the ANOVA analysis results were significant at a level of 0.05. The results of the regression analysis demonstrated that the unstandardized coefficient of 0.43 ($t = 2.84, p < 0.05$) was statistically significant. Furthermore, the $R^2$ value of the grade motivation construct was 0.08, and the ANOVA analysis results were statistically significant at a level of 0.05. Additionally, the unstandardized coefficient of 0.55 ($t = 2.7, p < 0.05$) was also statistically significant. The $R^2$ value of the understanding construct, which dealt with the learner’s understanding of the educational content, was 0.3, and the ANOVA analysis results were significant at a level of 0.01. The results of the regression analysis found the unstandardized coefficient to be 0.69 ($t = 6.02, p < 0.01$).

3.2. Analysis of Middle School Students’ Questionnaire Results

The results of analysis of the middle school students’ questionnaire responses are as follows. The Cronbach’s alpha was 0.98, which indicates a very high degree of reliability. Table 4 shows the results of the descriptive statistical analysis. For all seven constructs, the skewness value did not exceed 3 and the kurtosis value did not exceed 10.

Table 4. Analysis of descriptive statistics for middle school survey response.

|                | N  | Min | Max | Mean | S.D. | Skewness | Kurtosis |
|----------------|----|-----|-----|------|------|----------|----------|
|                | Statistics | Statistics | Statistics | Statistics | Statistics | Std. Error | Statistics | Std. Error |
| Motivation     | 55 | 3.00| 7.00| 5.76 | 1.25 | −0.58    | 0.32      |
| Self-efficacy  | 55 | 3.20| 7.40| 5.75 | 1.29 | −0.46    | 0.32      |
| Self-determination | 55 | 2.80| 7.00| 5.63 | 1.31 | −0.64    | 0.32      |
| Career Motivation | 55 | 2.40| 7.00| 5.65 | 1.29 | −0.47    | 0.32      |
| Grade Motivation | 55 | 1.60| 7.00| 5.34 | 1.36 | −0.54    | 0.32      |
| Understand     | 55 | 3.80| 9.00| 5.98 | 1.29 | −0.39    | 0.32      |
| Teaching Method | 55 | 4.00| 7.40| 5.89 | 1.17 | −0.41    | 0.32      |

The results of the regression analysis of the middle school questionnaire participants are as shown in Table 5. The results indicate that the questionnaire data could be utilized statistically as the tolerance value was greater than 0.1 and the VIF value was less than 10 for all the constructs. According to the results of the regression analysis, Science Level Up was found to have a positive impact on learner motivation.

The $R^2$ value of the motivation construct had an explanatory power of 0.26, and the results of the ANOVA analysis were significant at a level of 0.01. The unstandardized coefficient for the motivation construct was 0.49 ($t = 4.26, p < 0.01$). The results of analyzing the self-efficacy construct indicated that the $R^2$ value had an explanatory power of 0.30, the ANOVA analysis results were significant at a level of 0.01, and the unstandardized coefficient was 0.55 ($t = 4.81, p < 0.01$). It was also determined that the $R^2$ value of the self-determination construct had an explanatory power of 0.30. Additionally, the results of the ANOVA analysis were significant at a level of 0.01, and the unstandardized coefficient was 4.72 ($t = 4.27, p < 0.01$). The results of analyzing the career motivation construct determined that the $R^2$ value had an explanatory power of 0.48, and the ANOVA analysis results were significant at a level of 0.01. The results of the regression analysis revealed that the unstandardized coefficient of 0.48 ($t = 4.01, p < 0.01$) was statistically significant. Furthermore, the $R^2$ value of the grade motivation construct was 0.2, and the ANOVA analysis results were statistically significant at a level of 0.01. Moreover, the unstandardized coefficient of 0.47 ($t = 3.64, p < 0.01$) was statistically significant. Lastly, the $R^2$ value of the understanding construct, which dealt with the understanding of the educational content, was 0.61, and the ANOVA analysis results were significant at a level of 0.01. The results of the regression analysis demonstrated that the unstandardized coefficient was 0.71 ($t = 9.16, p < 0.01$).
Table 5. The effect of teaching method on learning effect and understanding.

| Model Summary | ANOVA | Coefficients | Collinearity Statistics |
|---------------|-------|--------------|-------------------------|
|               | $R$   | $R^2$        | $F$ | Sig. | Unstandardized Coefficients | Standardized Coefficients | Beta | Std. Error | Beta | T   | Sig. | Tolerance | VIF |
| Motivation    | 0.51  | 0.26         | 18.18 | 0.00 | 0.49 | 0.11 | 0.51 | 4.26 | 0.00 | 1.00 | 1.00 |
| Self-efficacy | 0.55  | 0.30         | 23.17 | 0.00 | 0.55 | 0.11 | 0.55 | 4.81 | 0.00 | 1.00 | 1.00 |
| Self-determination | 0.54 | 0.30       | 22.30 | 0.00 | 0.55 | 0.12 | 0.54 | 4.72 | 0.00 | 1.00 | 1.00 |
| Career Motivation | 0.48 | 0.23    | 16.10 | 0.00 | 0.48 | 0.12 | 0.48 | 4.01 | 0.00 | 1.00 | 1.00 |
| Grade Motivation | 0.45 | 0.20     | 13.22 | 0.00 | 0.47 | 0.13 | 0.45 | 3.64 | 0.00 | 1.00 | 1.00 |
| Understand    | 0.78  | 0.61         | 83.93 | 0.00 | 0.71 | 0.08 | 0.78 | 9.16 | 0.00 | 1.00 | 1.00 |
4. Discussion

Based on the analyses, it appears that using Science Level Up positively affects the motivation, self-efficacy, self-determination, career motivation, grade motivation, and understanding of learners. This positive impact could be attributed to the method used which offers learning experiences that differ from those of traditional teaching methods. The use of gamification provides gameful experiences [17] through which learning experiences are reinforced. Furthermore, such reinforced experiences have a positive effect on learner motivation [18]. This principle is also applied to learners who used Science Level Up.

Additionally, instructors ensure that learning is sustainable by stimulating the affordances of learners [19]. An affordance is a device that encourages learning and facilitates a degree of sustainable learning above a certain level [19]. A gamified learning program promotes a learner’s engagement in learning activities through missions and quests. To achieve this, and to design the missions and quests, instructors take the learners’ abilities, such as their prior knowledge and skills, into consideration. If a large gap exists between a learner’s abilities and the level of difficulty of the task, they may give up on learning the educational content [15]. However, because the missions and quests designed by Science Level Up had an appropriate level of difficulty, they had a positive effect on learner motivation. Those who successfully learned with gamification expanded their knowledge through activities in which they used the knowledge that they had gained. Furthermore, it was interpreted that the learners’ expanded knowledge had an impact on their career and grade motivation.

It is assumed that Science Level Up has a positive impact on the learner’s understanding of educational content as it delivers relatively difficult content in an enjoyable way that makes it easier to understand. A gamified learning environment provides the learner with multiple opportunities to attempt to learn. During these attempts, the learner expands their knowledge or supplements the inadequate areas by interacting with other learners [11]. Through this process, the learner begins to believe that the educational content that they had found difficult has been made more understandable and the problems can be solved easily. Furthermore, when they successfully solve the problems that they had perceived as being difficult, they enjoy the experience [15]. This indicates that sustainable learning is being realized.

5. Conclusions

This study investigated the effect that gamified online learning programs have on learner motivation and understanding of educational content. This study is intended to develop a method to create a sustainable learning environment amidst the COVID-19 pandemic. The results indicate that gamified online learning programs have a positive impact on the motivation, self-efficacy, self-determination, career motivation, and grade motivation of learners, while also facilitating their understanding of educational content.

This study proposes a method to achieve the Sustainable Development Goal 4 (SDG 4). These goals are based on the slogan “leave no one behind” and have been adopted by the 193 member states of the United Nations. The purpose of these goals is to ensure that the Earth’s natural resources are managed sustainably and are passed on to future generations. Gamification is being utilized to work towards and achieve humanity’s SDGs. Souza et al. [20] suggested that using gamification to develop programs may help to alleviate some of the environmental damage that is caused by overtourism.

Of the 17 goals included in the SDGs, SDG 4 is intended to ensure that everyone has access to quality education that is equitable. In particular, the purpose of SDG 4 is to ensure educational opportunities for people who cannot receive education due to physical or technical issues or because they live in developing countries. This study has been conducted to establish that gamification is an effective tool that can be used during the COVID-19 pandemic to overcome the limitations of traditional teaching methods and to reduce the educational inequality caused by the growing digital divide [21]. The following types of learners are the target of the SDG 4: learners residing in alpine regions, such as Mongolia.
or Nepal; learners in Sub-Saharan Africa; and female learners who experience educational inequality because of religious and cultural factors. Gamified learning programs and ICT technology are being used to research methods that can provide learners with quality education [22,23].

This study proposes that gamified online learning programs, based on the national curriculum, should be developed and distributed. Most countries invest in education to provide people with adequate educational opportunities. If people could learn with their smartphones or computers, it would be possible to provide an adequate learning environment for even those people who are unable to continue learning due to physical or technical issues. Additionally, numerous activities are now being conducted without face-to-face interaction due to COVID-19. Consequently, the level of fatigue that learners experience due to online learning has increased considerably [1]. Therefore, gamification must be utilized to minimize the burden on learners.

The limitations of this study and direction for future study are as follows. The learning program used in this study focused on comprehensive scientific knowledge, therefore, elementary and middle school students could benefit from the use of this program. Future studies that analyze the educational impact of such programs in detail should focus on the formal national curriculum, create customized learning programs for elementary and middle school students, and verify their effectiveness. Because high school and college students were excluded from this study, additional research must be conducted to develop gamified learning programs for those educational levels and to verify their effectiveness. Furthermore, online learning should incorporate personal factors such as individual learners’ educational needs and learning styles and their desire to learn. Using regression analysis, this study verified that gamification affects the motivation of learners when used in online learning. Future studies should further explore the role of gamification in online learning, as well as other factors related to the online learning environment examined through previous studies. Such studies should conduct further experiments to verify these methods in order to establish a sound program that supports sustainable online learning.

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