## Exploring the Effects of Progression Mechanics in Competitive and Collaborative Gamified Learning

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**Abstract:** This study investigates how competitive, collaborative, and progressive game-based and gamification learning mechanics influence children's motivation, engagement, and learning outcomes. The research was conducted with primary school children in an e-learning context delivered by the University of Central Lancashire's (UCLan) eLearning platform – Learnvoy - and specifically explored how the sense of progression, competition, and collaboration in a gamified environment influenced learners' academic performance.

This study involved groups of primary school learners in a quasi-experiment. The control group engaged in a traditional eLearning setup where they were asked to watch a few plain monologue tutorial videos and answer related questions. Two experimental groups participated in a gamified eLearning environment that used the same tutorial videos, but in which their answers powered up in-game characters: in one case creating a competitive experience and in the other a collaborative experience. After viewing each tutorial video, each learner answered the same questions as the control group, but here their rate of correctness powered up, or hindered frogs, from reaching a princess in a game based on the story of The Princess and the Frog. In this way, competitive, collaborative, and progressive elements were introduced in the game, where learners with higher accuracy in the question and answering activities had a better chance of winning, thus fostering an environment of motivation and achievement.

The results indicate that both experimental groups exhibited improved motivation, engagement, and accuracy compared to the control group; there was no significant difference between the two gamified conditions. These results are interesting to schoolteachers and eLearning creators seeking to integrate innovative and effective learning strategies into their educational curriculums. The findings underscore the potential of competitive and collaborative game mechanics, particularly progression elements, in enhancing learners' learning experiences and outcomes.

In conclusion, this research highlights the educational value of competitive, collaborative, and progressive digital game-based learning mechanics, suggesting that the sense of progression, competition and collaboration conveyed by such games can play a role in fostering learners' academic success.

**Keywords:** competitive gamified learning, collaborative gamified learning, progressive gamified learning, lesson gamification, learner engagement, learning progression embodiment.

## 1. Introduction

Traditional forms of learning can sometimes be seen as passive and potentially unengaging, especially when they involve activities such as listening to lectures or reading textbooks without interactive components. This passivity and lack of engagement is one reason why educators and researchers are interested in more active and engaging teaching strategies, such as digital game-based learning (DGBL), a type of learning where games are used to deliver educational content, and gamification, which involves incorporating game-like elements into learning (Al-Azawi, Al-Faliti and Al-Blushi, 2016). Whether DGBL or gamification is implemented online or offline, the principles of how they operate, and their potential impact on learning and motivation, remain largely the same. As online learning requires self-motivation and self-directed learning from students (Stark, 2019), it is hypothesised that DGBL or gamification can help support these aspects and bolster engagement (Fatta, Maksom and Zakaria, 2019).

This study began with a literature review on engagement within games, digital game-based learning, and gamification, leading to the creation of a PEG (Progression Embodiment Graph) illustrating the relationship between progression, feedback, and engagement. This graph then informed the design of a novel gamification setup. Through experimental testing, this setup demonstrated improved engagement outcomes, as shown by the collected data.

## 2. Literature

### 2.1 Why Engagement Is Important

Learner engagement is widely recognised as a crucial factor in successful learning, as it promotes learning retention and fosters a positive learning environment (Kahu, 2013). Research has consistently shown a positive correlation between learner engagement and academic achievement. Engaged learners generally perform better academically (Schunk and Mullen, 2012) and for primary school aged children, engagement in learning is a predictor of future academic success (Ladd and Dinella, 2009).

### 2.2 Engagement in Games

The game industry has extensive knowledge about creating engaging experiences, as creating engaging products is the key to surviving. If players find a game engaging, they are more likely to continue playing it over time, potentially leading to higher revenues from in-game purchases, advertising, and other monetisation strategies (Hamari, 2015). One aspect that makes games engaging and sometimes addictive is their provision of immediate feedback. Feedback often comes in the form of scores, progress bars, level-ups, rewards, or direct responses to the actions that players take. This instant feedback is an essential factor in player engagement as it allows players to see their progression in real-time, which can be rewarding and motivating (Juul, 2010).

Instant feedback in games can be considered both an extrinsic and an intrinsic motivator, depending on the context and how the player interprets it. As an extrinsic motivator, instant feedback often comes as rewards or penalties. The desire to achieve these rewards is driven by external factors. As an intrinsic motivator, it provides players with a sense of mastery and competence. This form of motivation comes from within the individual, who is driven by the satisfaction derived from personal achievement and the inherent enjoyment of the task itself (Ryan, Scott and Przybylski, 2006). Since the feedback mechanic in games can be simultaneously extrinsic and intrinsic, and a combination of intrinsic and extrinsic motivation tends to be most effective, it provides one explanation for why some games are so engaging or even addictive (Ryan and Deci, 2000; Przybylski, Rigby and Ryan, 2010).

In education, the idea that timely feedback on progression is crucial also prevails. The longer a delay between a learner's action and the feedback on that action, e.g., submitting an assignment or answering a question, the less likely the learner will make a strong connection between their action and its outcome. This can reduce their engagement and motivation in the learning process (Stott and Neustaedter, 2013).

### 2.3 Engagement in Digital Game-based Learning

The DGBL field draws heavily from principles of game design and psychology to create engaging and educational experiences (Van Eck, 2006).

**Figure 1:** Prodigy – a screenshot taken from prodigygame.com in 2023

DGBL inherits the instant feedback mechanics from game design to motivate learning, as it allows learners to see the immediate impact of their actions and encourages them to adjust their strategies and efforts to improve their outcomes (Plass, Homer and Kinzer, 2015; Zeng et al., 2020). The feedback provided closely relates to the game's storyline or objectives. For instance, Prodigy is an online digital game-based learning platform for grades 1-8 that covers over 1,400 crucial math skills. As students play, they answer maths questions to progress in the game. Players who make a mistake may take damage or face other in-game consequences. Figure 1 is a screenshot from Prodigy, where players answer questions to defeat enemies. The embodiment of progression is presented as the health bars.

While DGBL offers numerous advantages, there are also potential drawbacks. For example, developing effective educational games can be time-consuming and costly, and if not designed correctly, the gaming elements can distract learners (Pasqualotto et al., 2023). For example, in Minecraft: Education Edition, improper illumination by a player can accelerate enemy spawns, and the player may spend much time repelling the enemy instead of learning, besides a significant amount of time wasted on learning the complex system.

## 2.4 Engagement in Educational Gamification

While aligned to motivate and engage learners, educational gamification can offset some of the challenges inherent in DGBL. Gamification typically involves adding game elements such as points, badges, or leaderboards to existing learning activities, which can be less resource-intensive (Al-Azawi, Al-Faliti and Al-Blushi, 2016) and potentially less distracting. For example, a point system can be directly tied to learning objectives. The points accumulate quietly in the background and do not require prompt reactions from the learners, reinforcing rather than detracting learners from the educational content.

Duolingo is a language learning platform that uses gamification extensively. It uses a path to embody learning progression (Figure 2) which acts as a motivator (Sun and Hsieh, 2018).

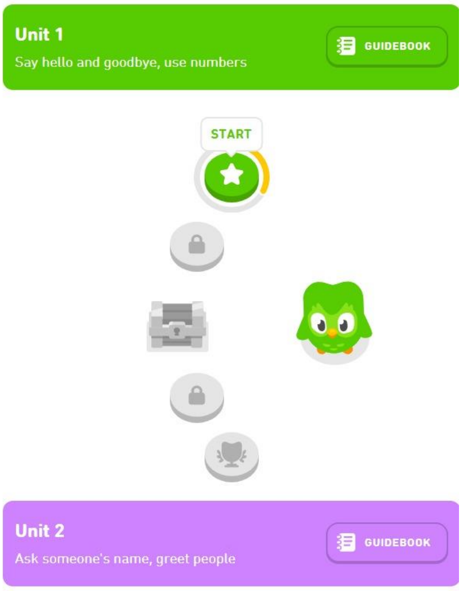


**Figure 2:** Duolingo – a screenshot taken from duolingo.com in 2023

Like DGBL, gamification also has potential drawbacks, such as overemphasising extrinsic rewards, as the standard game elements applied are considered extrinsic (Hanus and Fox, 2015). To implement gamification well, incorporating elements that drive intrinsic motivation and foster a sense of progress and competence is essential (Kapp, 2012).

## 3. PEG (Progression Embodiment Graph)

### 3.1 The Relationship between Progression, Feedback, and Engagement

Setting aside the various deliveries of blended game elements and learning context, the elements underlying engagement are feedback time and progression embodiment, as the above literature review indicates. The relationships between these elements are shown in Figure 3. In this graph, the X-axis is feedback time which is the time between the learner completing a task and the 'system' giving feedback on whether this is correct or not. The Y-axis is progression towards the completion of the learning task. Together with the starting point 0, their coordinate produces an engagement angle. The bigger the angle is, the more engaged the learner is. For example, if it takes 100 years to learn a subject, the engagement angle will be very close to zero. However, if it takes 1 second to complete the learning, the engagement angle will be close to the maximum and would represent an activity that individuals could embark on and complete immediately. The 100% progression doesn't necessarily represent the entirety of the learning journey. Instead, it can apply to any subset of tasks within the larger learning process. Furthermore, this progression can be visualised or represented in various forms. If the embodiment of progression can convey a combination of intrinsic and extrinsic motivation, it will enlarge the engagement angle.

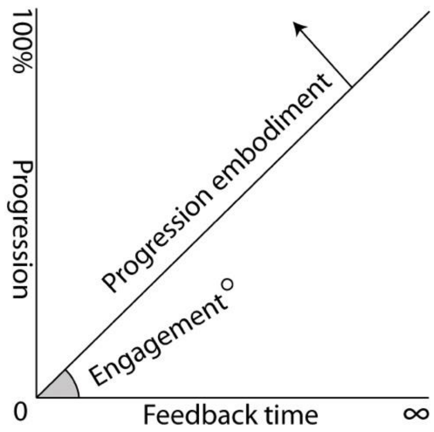


**Figure 3:** The PEG (Progression Embodiment Graph)

### 3.2 Research Question and Hypothesis

Ample research indicates the positive impact of immediate or timely feedback on learning progression. In our research, we explore the effect of additional intrinsic (collaboration) and extrinsic (competition) on engagement as measured by recall tests and self-report. The question being answered is *'Does the addition of motivating game elements have an effect on learning, and if so, is there a difference between competitive and collaborative game elements?'* Our hypothesis is that '*For a simple focused learning activity, the addition of a game, that offers additional intrinsic or extrinsic motivation, will result in greater engagement as measured by recall tests.'*

## 4. The Study

### 4.1 Participants

The study took place at the UCLan Mess Day event in 2023. Fifty-four children aged between 8-9 participated on several different days. Only four claimed to be non-native English speakers, but he/she did not struggle with the lesson. The control group consisted of 26 participants. Two experimental groups each had 14 children in them.

### 4.2 The Learning Materials

Since the hypothesis is related to the gamification of education, a teaching subject had to be selected. It was important to choose something that the participants were not already familiar with, while also ensuring it was easy to understand to ensure learning takes place. The anticipated participants were Year 5/6 pupils, and according to the National Curriculum in England: primary curriculum, Big Data was a topic not explicitly covered in their curriculum. However, some elements of data science are included in computing, mathematics, science, geography and history courses (England Department for Education, 2023), so in this case, the participating children should know something about data but little about Big Data. Therefore, Big Data was chosen as the topic to present to the participants. The participating children were going to be aged between 8 and 9 and as it is accepted as a guide that a child has an attention span of 2 to 3 minutes per year of their age Altun, Hazar, and Hazar (2016), the learning activity for this was intended to only take around 20 minutes. The topic was divided into four lessons, each lasting around 5 minutes. Each lesson consisted of a one-minute video tutorial and a four-minute question-answering section. The four Big Data videos are Introduction (1:02), Collecting (1:07), Analysing (1:10) and Applying (1:36). There was nothing especially technical in the videos, only brief descriptions of Big Data in those four areas.

### 4.3 The Gamification – Integrating a Small Game alongside the Lessons

The next step was to create a small game to integrate alongside the lessons as a motivator. The main functionality of the game was to convert the correctness rates of children's answers into progressions. Integrating a game into the eLearning environment positions our approach at the intersection of DGBL and gamification. However, since the game itself didn't contain educational content and its gameplay didn't directly facilitate learning, but primarily served as a mechanism to reflect learners' progression, it leans more towards gamification.

Like most games, the game needed a storyline and objectives. The fairy story 'The Frog and the Princess' was chosen as the background: *Once upon a time, a frog kissed a sleeping princess, and the frog turned into a prince. Now another princess had been found sleeping for a long time. The whole frog kingdom heard the news, and all male frogs started heading towards the princess's castle. A prince of the neighbour kingdom received the report and set off immediately to rescue the princess, but it took time. Before the prince's arrival, the castle launched missiles to push back the frogs* (Figure 4).


**Figure 4:** The learning experience structure - video – questions – game; repeated four times

Competition and collaboration were chosen as the vehicles of extrinsic and intrinsic motivation (Abuhamdeh and Csikszentmihalyi, 2009; Kong, Kwok and Fang, 2012). Therefore, there were two modes of the game which were studied in the two experimental conditions. In one mode, the participants played as the frogs (competition) and the other as the castle missile (collaboration). Hence we could explore if there were any differences between competition and collaboration in engaging the participants. The nature of interaction in competition and collaboration guided the design of the two modes. That is, in the competition mode, participants work against each other, trying to be the best in the group, and in the collaboration mode, participants work together to achieve a common goal.

#### *4.3.1 The Competition Mode*

For the participants who played as frogs in this game, each frog had a number above them. A user ID could be found at the top of the website. The participants could identify their frogs by associating the ID and the frog number. The accuracy of their answers powered up the resistance of the frog. The more questions they answered correctly, the less distance the missiles pushed back their frogs. If one reached the castle before the prince arrived, that person won the game. When the participants powered up their frogs, they competed to reach the castle.

### 4.3.2 The Collaboration Mode

For the participants who played as a team, they powered up the missiles launched by the castle in the game. Initially, the missile speed was very slow. The accuracy of their answers increased the speed of the missile; the faster the missile, the quicker it could push the frogs back. If the children playing survived until the arrival of the prince, they won. When the participants powered up the missile, they collaborated to keep the frogs away from the castle.

### 4.3.3 The Embodiment of Progression

After watching each of the four learning videos, the participants answered the questions and then watched how their characters performed. In each learning section, they saw their frogs getting closer to the castle or the castle missiles pushing the frogs back. The distance between the castle and the frogs in the competition mode and the speed of the missile in the collaboration mode are the embodiments of progression.

## 4.4 Instruments for Measuring

### 4.4.1 Recall Questions to measure Engagement.

Memory and attention are often considered early indicators of engagement; if learners are paying attention, it is likely that they are engaged. Similarly, if they can recall information, it is likely that they are paying attention (Alves Durães, 2018; Sarter and Lustig, 2009). Memory can be easily measured through recall tests (Roediger and Karpicke, 2006), which can be easily managed by eLearning systems, likewise UCLan's Learnvoy. Hence, it was decided to apply recall tests to measure engagement in this study. Questions consisted of two types only: direct memory and memory with context. For the direct memory, the question was, "Which word is used in the video?". Consistency was kept in plural, singular, and tense for answer options to match the words used in the videos. For the memory with context, to avoid guessing the answers, the incorrect options still sounded plausible (see Figure 4).

### 4.4.2 Experience Survey

A short survey was designed to get feedback on the learning, and on the two game modes (see Table 2) and to capture children's experienced fun (Read, MacFarlane and Casey, 2002). An open-ended question was used to elicit opinions on whether children would recommend the game to their peers.

## 4.5 The Participant Groups

The participants were divided into control and experimental groups. The control group took the lessons without gamification, and the experimental groups learnt with gamification in one of two modes: competition and collaboration (Figure 5).

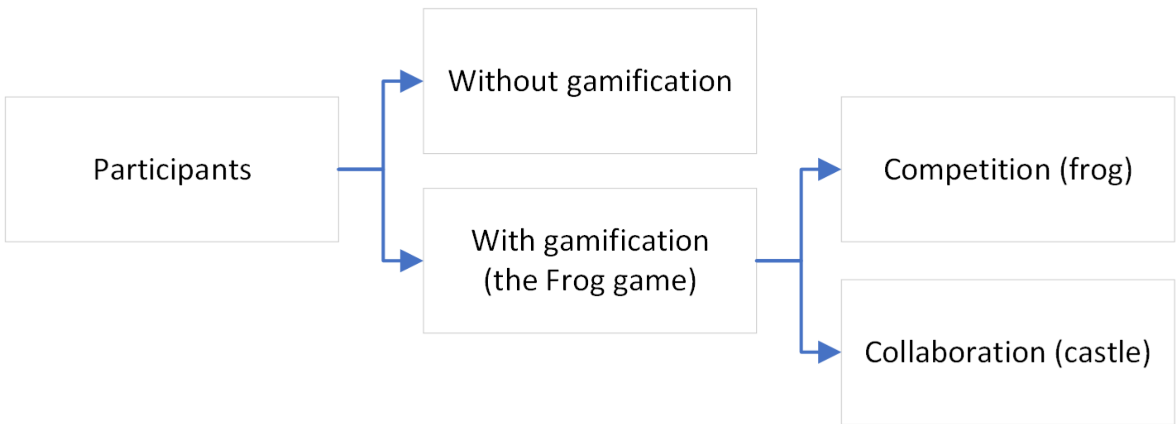


**Figure 5:** Participant groups

## 4.6 Procedure

Children came to the University labs to do the study. They were greeted in the labs by a senior researcher who gave a talk about safety and about assent, stressing that children could choose to not participate if they wanted to. Children were put into groups to complete a series of different activities on the day. The present study was the only activity that was concerned with learning and Big Data and children came to it in groups of between 12 and 15. After sitting down at individual PCs attached to the University network, which had the software installed, an instruction video was played to the children to inform them what they should expect and do. Each group that came to the session did a different set up – two groups did the control condition with no gamification (26 children) and the other two did the competition (14 children) and collaboration (14 children) experimental conditions. Children were placed into mixed-ability groups by the teachers; each followed the following steps:

- Step 1: Answering personal questions – Children were asked if they knew about Big Data and about their first (native) language. These questions were only used for screening as any child who claimed lots of knowledge about Big Data, or who had very poor English, would have their data excluded.
- Step 2: Watching videos - Children watched the first of four videos about big data.
- Step 3: Recall Questions - After watching each video, children were given the password to unlock the questions to answer relevant questions from the video. To encourage attention and discourage picking an answer randomly, participants only had one chance to answer each question. This was also designed to emulate a gaming experience, where each decision can result in either rewards or repercussions. After completing the answers, the two gamification groups were taken to the frog game to see how their answers powered up the characters in the game.
- Step 4: Repeat Steps 2 and 3
- Step 5: Experience Survey

# 5. Results

Assuming all variables were the same for all the groups and only the designed gamification was employed to reinforce engagement (Figure 6), the two gamification groups were expected to answer more questions correctly and express greater appreciation for the experience than the control group.

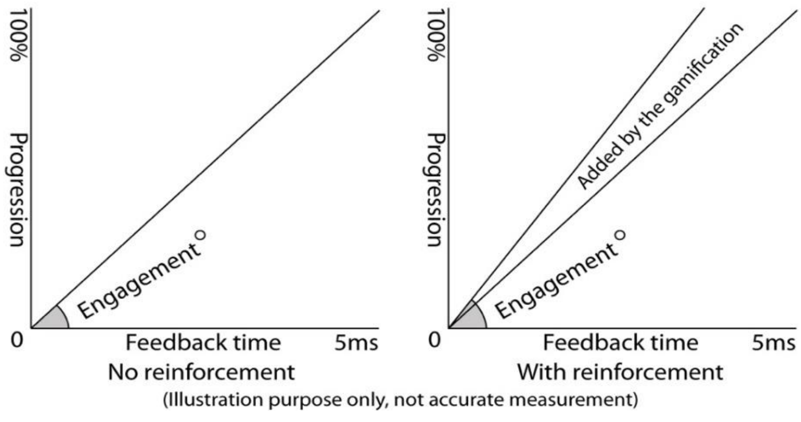


**Figure 6:** Engagement reinforced by the designed gamification.

### 5.1 Learner Performance

Each correct answer from a child was scored as 1 point and a score recorded for each of the four instances of answering. Given that the child only experienced the game after having answered the first set of questions, any effect of the game on answering would be expected after that moment – viz. there would be shown to be an effect if the scores for the last three videos from the experimental groups were significantly better than the scores of the last three videos from the control groups. Similarly, if the scores for the first video were not significantly different across the three groups (control and two experimental) then we could surmise that any effect seen from gamification as independent of the group make-up. Table 1 shows the percentages of all correct answers across the groups.

There was no significant difference between the performance of the experimental groups (*M* = 3.5, *SD* = 1.02) and the control group (M = 3.31, SD = 1.17) in the answers to the first set of questions, *t*(52) = -0.634, *p* = .529. This can give confidence that the children in the different groups were not especially different in their ability and focus at the start of the activity.

**Table 1:** The accuracy of answering the questions from each group.

| | Control group | Competition | Collaboration | Both gamification groups |
|---|---|---|---|---|
| Introduction | 55.13% | 58.33% | 58.33% | 58.33% |
| Collection | 54.49% | 59.52% | 59.52% | 59.52% |
| Analysis | 67.95% | 77.38% | 72.62% | 75.00% |
| Applying | 57.05% | 78.57% | 64.29% | 71.43% |

The experimental groups (M = 12.36, SD = 2.38) performed significantly better in their answers to the final three sets of questions, *t*(52) = -2.423, *p* = .009, than the control group (M = 10.77, SD = 2.34) which answers the first part of the research question in regard to improvements in performance being made with the addition of the gamification.

For the second part of the question, a comparison was made between the scores on the last three sets of questions between the two experimental conditions. Despite higher average scores, there was no significant difference, *t*(22) = 1.262, *p* = .218, between the competitive condition (M = 12.93, SD = 2.55) and the collaboration condition (M = 11.79, SD = 2.04). This answers the second part of the research question but also suggests that this would merit further study.

### 5.2 Children's Experience

Subjective opinions were gathered from all the children about learning with the videos and the question / answer protocol and the gamification groups (collaboration and competition) were additionally asked about the experience of having the frog game associated with the learning activity. Table 2 shows that about 80% of the participants reported being motivated, by the games, to engage in the learning activity.

**Table 2:** The percentages choosing Yes to the questions.

| | Competition | Collaboration |
|---|---|---|
| Did the frog game make you want to pay attention more? | 85.71% | 84.62% |
| Did you want to answer more questions right because of the frog game? | 78.57% | 84.62% |

An open-ended question in the survey asked: Would you tell your friends to play this game? Why or why not? This is an optional question. Generally, the majority said, "Yes, it is fun", which matches the enthusiasm when the participants took the lessons. The feedback from the competitive group was eleven positives and one negative. "No" was the comment from the negative one. The feedback from the collaboration group was nine positives and four negatives. The four negative comments are (with the children's typos):

- "No, because it's not a true game that people would play because it's a learning game."
- "No, because there are other learning that teach different things."
- "No, because it was about work."
- "I don't really know because I don't know the name of the game."

This feedback suggests that children preferred the competitive set up for the game.

## 6. Discussion

It appears that the addition of a small game to create higher engagement might assist children in learning. The groups who experienced the games scored more highly on the last sections of the learning activity suggesting that there was an effect. It is not clear what this effect was – it could be that the game created more intrinsic or extrinsic motivation – as was theorised or it could be that simply having that break in the learning created a better learning experience. Further studies would be needed to investigate this. On the face of the scores (see Table 1), adding competition seemed to have a greater effect on learning but given the small numbers and the lack of any significant difference, this would need to be studied with larger samples. Other studies on motivation in digital games (Lomos, C., Seineke, U., Kesting, F. and Luyten, J.W., 2023) suggest that systems that promote extrinsic motivation (like competition) have a negative effect on building students' intrinsic motivation and so an interesting follow on to this work is to explore how collaboration can be built into the learning activity. One important feature of our work is that the game is an add-on to the learning activity – that is to say, that the scores power the game. Using the same protocol with other learning activities is an obvious follow on, as is using it with other children. Of interest in both these cases might be to see how collaboration and competition relate or differ in keeping children focussed and on whether different ages exhibit differences.

Our research question was answered in so far as it was shown that gamification improved learning and this supported our hypothesis. Returning to the PEG, children's self-responses as well as the learning data showed an increase in engagement as theorised.

**7. Conclusion**

This study tested the hypothesis that '*For a simple focused learning activity, the addition of a game, that offers additional intrinsic or extrinsic motivation, will result in greater engagement as measured by recall tests.'* This hypothesis was developed from the conclusion of the literature review on the relationship between progression, feedback time and engagement. Engagement was measured through recall tests. In the study, the focused learning lasted for around five minutes in each lesson, four lessons in total. Whether five minutes is the optimal length remains unknown, but the data gathered shows the feasibility of the hypothesis.

The participants aged 8-9 came from four primary schools and were divided into control and experimental groups. The experimental group was further divided into competition and collaboration groups. Based on the quantitative data gathered, the experimental group achieved better scores than the control group, and the qualitative data testify that the participants were motivated to engage in the setup guided by the hypothesis.

This research provides a foundational stone for further gamification study in this direction. The research data indicate a preference tendency between the competition and the collaboration modes, which can be the next step of the research. More components can be added to this gamification method later to enrich the booming of blended teaching – the mixture of traditional and online teaching after the impact of Covid-19.

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