IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education 2026, volume 15, issue 1

TANGIBLE OR INTANGIBLE: IS THAT A DILEMMA FOR GAMIFIED FLIPPED LEARNING IN PRIMARY SCHOOL MATHEMATICS?

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Received: August 13, 2025 **Accepted:** March 30, 2026 **Published:** March 31, 2026

Suggested Citation:
Karamert, Ö., & Demirkan, Ö. (2026). Tangible or intangible: Is that a dilemma for gamified flipped learning in primary school mathematics?. *International Online Journal of Primary Education (IOJPE), 15*(1), 56-80.
https://doi.org/10.55020/iojpe.1764363

Abstract

Gamification plays an important role in flipped learning environments. Recent studies underscore the effectiveness of gamified approaches within these settings, but also indicate that most designs for gamification are predominantly digital-based. This study aims to explore the competition between tangible (physical) and intangible (digital) forms of gamification in the context of flipped learning. Specifically, it assesses the impact of both tangible and intangible gamified flipped learning approaches on students' mathematical literacy self-efficacy beliefs and their engagement levels towards learning activities. The study group for this quasi-experimental study was composed of 69 fifth-grade students from a public school in Türkiye. The study group was separated into three groups: two experimental groups (tangible and intangible) and one control group. The findings indicate that both tangible and intangible gamification in a flipped learning environment have a positive impact on students' personal experience of their mathematical literacy self-efficacy beliefs. However, neither approach had a significant impact on students' engagement levels. These results suggest that gamified flipped learning could be an effective strategy for enhancing students' personal experience of their mathematical literacy self-efficacy beliefs at the primary education level. The study provides pedagogical implications based on these results and offers recommendations for future research.

Keywords: Gamification, flipped learning, primary education.

INTRODUCTION

Technological developments in our age have brought about fundamental changes in learning processes in educational environments. Educational technology is area that has been deeply affected by these changes. The modern age has created new educational needs, which in turn have caused the advent of innovative educational technologies. Traditional methods are no longer sufficient to achieve contemporary learning goals. There is a growing need for new student-centred learning approaches that can enhance learning environments with technological capabilities. One of the prominent approaches, the flipped learning approach, is gaining increasing attention in learning environments.

The flipped learning approach, which attracts attention with its potential to transform educational environments, is defined as a pedagogical approach in which the traditional learning environment is reversed (Bergman & Sams, 2023). Its main goal is to provide sufficient time for practical experience-based learning in school by enabling theoretical knowledge to be learned outside of class. Flipped learning extends the time allocated for activities such as problem-solving, discussion, and peer interaction in the classroom by transferring the theoretical knowledge acquisition process outside of the class environment using technological tools. Thanks to this feature, flipped learning allows classroom time to be allocated to in-depth learning activities, creating more time for meaningful learning and the development of higher-level skills for students (Bishop & Verleger, 2013; Sargent & Casey, 2020).

Flipped learning not only offers students the opportunity to learn theoretical knowledge at their own pace, but also removes teachers from their role as presenters and transforms them into guides who deepen learning (Bergman & Sams, 2023). Flipped learning is frequently preferred by teachers today due to its advantages. Although flipped learning provides significant benefits in terms of learning objectives, it faces challenges related to students' self-efficacy and engagement in learning activities (Hao & Fang, 2024; Li & Li, 2022).

Recent studies show that, despite the apparent benefits of flipped learning, students' self-efficacy and engagement levels in the learning process are not high enough (Li & Li, 2022; Lo & Hew, 2021; Sailer & Sailer, 2021). The low level of students' self-efficacy beliefs and active engagement in learning activities is cited as one of the factors contributing to the reduced effectiveness of the flipped learning approach (Ahmed & Asiksoy, 2021; Hwang et al., 2015). This situation may prevent students from effectively learning the theoretical prerequisites for meaningful learning (Lo & Hew, 2020). A review of the literature reveals that the flipped learning approach is supported by auxiliary approaches to overcome this problem (Sanz-Angulo et al., 2025). In particular, student-centred approaches aimed at increasing student motivation have been found to help solve existing problems in flipped learning (Xiao & Hew, 2024). Among these approaches, gamification stands out prominently (Ekici, 2021; Ng & Lo, 2023). Flipped learning supported by gamification is an effective strategy that has the potential to positively influence students' approaches to learning objectives (Candel et al., 2024; Do et al., 2023; Gutierrez-Gonzalez et al., 2023).

Gamification is defined as the integration of game design elements into non-game contexts (Deterding et al., 2011; Zichermann & Cunningham, 2011). The main idea behind gamification is to use the motivational features of games to make learning activities more interesting for students (Kapp, 2012). The basic aim of gamification, which is related to Self-Determination Theory proposed by Deci and Ryan (1985), is to influence participants' internal and external motivations positively and thus increase their motivation and commitment to a specific goal (Dominguez et al., 2013; Hamari et al., 2014). Gamification attracts attention with its potential to influence students' active engagement and commitment to learning goals in educational settings (Hanus & Fox, 2015; Majuri et al., 2018; Xiao et al., 2021). Current research shows that gamification can yield positive results when used to increase motivation, academic achievement, engagement, and self-efficacy (Hao & Fang, 2024; Huang et al., 2026; Pan et al., 2026; Yllana-Prieto et al., 2021). In this regard, gamification can help overcome the current self-efficacy and engagement problems related to the out-of-class process of the flipped learning approach through its components, such as avatars, badges, and levels. In addition, it can contribute to creating the dynamism needed for the in-class process of the flipped learning environment.

Current studies show that digital-based software approaches are preferred for the gamification of flipped learning environments (Ekici, 2021). Although recent studies present results for gamification in various contexts of educational sciences, it can be observed that the focus is on digital-based platforms (e.g., Kahoot!, Quizlet, Quizizz, Socrative) in terms of implementation (Arsyad et al., 2024; Candel et al., 2024; Pratiwi et al., 2024; Zou, 2020). Contrary to popular belief, there is no requirement to use digital software for gamification (Dodero et al., 2014; Xiao & Hew, 2024). Although numerous studies have examined the effects of gamification on student motivation and achievement, most research considers gamification as a single instructional approach. However, gamification can be implemented through different design patterns, such as tangible and intangible elements, which may lead to different learning experiences (Dodero et al., 2014; Gennari et al., 2017). Despite this distinction, empirical comparisons of these two forms of gamification are limited, particularly in mathematics education contexts. Furthermore, few studies have examined how these approaches influence students' mathematical literacy self-efficacy and classroom engagement within flipped learning environments. Therefore, this study aims to compare the effects of tangible and intangible gamification on students' mathematical literacy self-efficacy beliefs and engagement in the primary flipped mathematics learning environments.

Gamification elements can be classified as intangible or tangible. In intangible gamification (completely digital, hybrid systems, or semi-digital), elements such as points, badges, leaderboards, and virtual rewards which represent the feedback process within the learning system are integrated into learning environments via digital learning platforms. In tangible gamification, however, gamification elements are designed to be physically tangible rather than relying on digital platforms. These tangible elements are thus integrated into the learning environment. Adaptability to learning objectives is fundamental in both types of gamification (Karamert & Kuyumcu-Vardar, 2021). Gamification elements can also be implemented using traditional approaches and paper-based platforms (Gennari et al., 2017; Xiao & Hew, 2024). There is a need for further research focusing on this gamification aspect. Research conducted in this direction can provide deeper insight and help make educational gamification more efficient for learning environments. The results obtained from studies conducted in this direction can contribute to the individualisation of the Gamified Flipped Learning (GFL) approach according to the purpose and environment in which it can be used. In other words, it can contribute to the design of a GFL approach that is more student-centred and personalised. Based on this, the present research was conducted to contribute to filling this existing gap. With the elimination of these uncertainties, gamification designs more suitable for learning environments can be realised. Thus, the present research aims to pinpoint which type of gamification is more influential in this regard in a flipped learning environment and to fill the gap in the literature on this subject.

This research was designed based on the main idea that tangible gamification can be as effective as intangible counterparts in improving students' self-efficacy and engagement levels in the flipped learning approach. The study aims to fill the existing gap in the literature by determining the effect of the flipped learning approach supported by tangible and intangible gamification on primary school students' Mathematical Literacy Self-efficacy Beliefs (MLSB) and engagement in mathematics course. The potential of gamification to increase internal and external motivation in students, when combined with the flipped learning supported by tangible and intangible gamification elements, offers a promising approach. The study focuses on this fundamental advantage of gamification. It aspired to identify the type of gamification that is most influential in enhancing students' MLSB and engagement in a mathematics course. Additionally, the research aims to deliver a practical guide for educators regarding tangible and intangible gamification. In this way, the study aims to inspire more innovative gamification designs for flipped learning environments.

The primary intent of this study, which focuses on two different types of gamifications in a flipped learning environment (tangible and intangible), is to investigate the extent to which a flipped learning approach enhanced with gamification elements changes primary school students' mathematical literacy skills compared to a traditional learning approach. Mathematical literacy skills are related to the ability to apply mathematics to everyday life and are highly critical skills in terms of mathematics education (Bakker et al., 2021; Bolstad, 2023; Throndsen et al., 2020). The development of students' abilities in this skill is an issue that needs to be addressed, as it can increase their beliefs about these abilities, that is, their self-efficacy beliefs (Ozgen, 2013). This objective is consistent with the individualised learning opportunities offered by the flipped learning approach and the structure of gamification, which increases students' motivation and self-efficacy beliefs. In this study, the flipped learning process was incorporated into the learning environment by linking pre-class and in-class learning activities with gamification elements. This is expected to affect students' MLSB positively. The second intent of the study is to investigate the extent to which the flipped learning approach, enhanced with tangible and intangible gamification elements, changes primary school students' engagement in mathematics courses compared to the traditional learning approach. Engagement is one of the critical components of learning environments (Sever, 2014; Wang et al., 2014). Since high levels of student engagement directly affect their academic achievement, it is considered an area that needs to be improved (Christenson et al., 2012; Fredricks et al., 2004). This objective is consistent with the student-centred structure of the flipped learning approach, which encourages engagement, and the structure of gamification, which directs students to participate in learning content actively. In the study, learning activities related to the flipped learning process are supported by gamification elements that encourage student engagement. This is expected to increase students' active engagement levels in learning activities.

The fact that the GFL approach is related to constructivist and self-determination theory is seen as agreeing with the student-centred structure of the current learning environment. This has recreated a noteworthy role in generating the objectives of this study. The present study, designed in line with these intents, endeavours to answer the research questions listed below.

1) Do primary school students' mathematical literacy self-efficacy beliefs differ in terms of the tangible gamified flipped learning, the intangible gamified flipped learning, and the traditional learning approach?

2) Do primary school students' engagement levels differ in terms of the tangible gamified flipped learning, the intangible gamified flipped learning, and the traditional learning approach?

This research presents promising results regarding the use of the GFL approach in the context of learning objectives. This study contributes to the literature by proposing a non-digital-based approach to the use of gamification in educational settings. Additionally, it is expected that the current research will serve as a helpful guide for educators on the integration of tangible and intangible-based gamification approaches into flipped learning environments. Moreover, this study contributes to primary school mathematics education in several key respects. Firstly, at the primary school level, where student motivation and engagement are particularly critical for learning, it provides empirical evidence regarding the implementation of different gamification structures within a flipped learning environment. Secondly, by examining the effects of tangible and intangible gamification elements, which have largely been overlooked in previous research, on students' mathematical literacy self-efficacy and engagement, it offers a comparative perspective. Finally, the study provides practical guidance for primary school teachers by underlining how different gamification designs can be integrated into classroom practice to assist active learning and student engagement in primary mathematics education.

Background

This section of the study examines the concepts that form the theoretical basis of the study. The study's background is established through an analysis of existing relevant research. First, the approach of GFL, which combines gamification and the flipped learning model, is discussed. This is followed by the examination of MLSB and engagement, which are the dependent variables of the study. Finally, a review of existing research related to the GFL approach is presented.

Gamified Flipped Learning

GFL is an innovative teaching approach that combines game design elements with the flipped learning model. In traditional flipped learning, theoretical instruction is typically provided through videos and digital content prior to the class, while class time is provided to active learning and problem-solving activities (Bergmann & Sams, 2023). By incorporating gamification elements, defined as the application of game design elements in non-game contexts (Deterding et al., 2011), into the learning environment, students' interest in learning objectives can be increased (Candel et al., 2024; Zainuddin et al., 2022).

The primary goal of the GFL model is to make the learning process more interactive and engaging, thereby increasing student engagement and motivation for learning objectives (Xiao & Hew, 2024; Zou, 2020). Gamification can increase the effectiveness of the flipped learning approach by improving students' motivation, collaboration skills, and problem-solving abilities through its game elements (Daliranfirouz et al., 2024; Do et al., 2023; Kapp, 2012; Lo & Hew, 2020). This model is implemented by conducting gamified classroom activities (e.g., group discussions or problem solving) following gamified pre-class teaching activities (e.g., instructional videos or digital content). The GFL model encourages students to engage in learning activities through game elements such as points, badges, and levels (Daliranfirouz et al., 2024; Ghafouri et al., 2024).

This hybrid approach prioritises student-centred and interactive learning experiences by reversing the traditional teaching structure (Thongmak, 2019). Game design elements are frequently used by researchers to overcome engagement problems encountered in traditional flipped learning models (Hao

& Fang, 2024; Li & Li, 2022) by utilising their entertaining nature (Ekici, 2021; Zainuddin et al., 2020). Additionally, by facilitating instant feedback and peer interaction during the learning process, it has the potential to support the development of 21st-century skills such as critical thinking, collaboration, and creativity (Marell-Olsson, 2021). By incorporating these features, GFL promotes active knowledge construction in learning environments and thus aligns with constructivist learning theory.

Mathematical Literacy Self-Efficacy Beliefs

Mathematical literacy can be defined as a cognitive ability that enables individuals to apply mathematics to real-life situations (OECD, 2022). In other words, mathematical literacy refers to the use of mathematical thinking to approach daily-life problems, rather than simply memorising formulas (Graven et al., 2023). Mathematical literacy is important not only for basic mathematical calculations but also for helping individuals make conscious decisions regarding logical thinking (Jablonka, 2015; Throndsen et al., 2020). Furthermore, current studies indicate that mathematical literacy is also related to creative thinking, digital literacy, and environmental literacy (Zeng, 2025). In this context, it can be said that mathematical literacy is an important competency that should be fostered in mathematics education.

The concept of self-efficacy, one of the components of Albert Bandura's Social Learning Theory, refers to individuals' judgements about their ability to plan and carry out actions to achieve a specific goal (Bandura, 1977). In other words, self-efficacy is an individual's awareness of their ability to cope with a situation they encounter. Self-efficacy can affect educational outcomes because it is related to characteristics such as student motivation and engagement (Zimmerman, 1995). The higher students' self-efficacy beliefs are, the more their motivation and engagement in educational goals increase (Bandura & Schunk, 1981). Therefore, considering that motivation and engagement are critical factors in mathematics education, it can be said that self-efficacy beliefs are of crucial importance (Schunk, 1991).

Mathematical literacy is accepted as one of the most fundamental skills for students' ability to understand mathematics in modern mathematics education (Höfer & Beckmann, 2009). How students position themselves in terms of these skills, and their motivation awareness, is related to self-efficacy beliefs (Bandura, 1977). In this context, MLSB refers to individuals' thoughts about their abilities concerning mathematical content encountered in social life (Özgen & Bindak, 2011). Self-efficacy beliefs in mathematical literacy abilities represent students' motivation and self-confidence in mathematics, as well as their ability to demonstrate determination in the problem-solving process (Pajares & Miller, 1994; Zimmerman, 2000). Students with high MLSB are more likely to show willingness and determination towards challenging mathematical tasks (Schunk et al., 2008), while students with low beliefs are more likely to exhibit avoidance behaviour associated with anxiety (Dweck, 2006; Stipek & Gralinski, 1996). Therefore, it can be said that improving self-efficacy beliefs regarding mathematical literacy abilities is a critical concept for increasing students' motivation and academic achievement. It is clear that educational programs should prioritise improving students' self-efficacy beliefs in mathematical literacy to enable the cultivation of competent individuals (Zakariya, 2022).

Engagement

Engagement refers to students' cognitive, emotional, and behavioural involvement in learning objectives (Wang et al., 2014). In other words, engagement refers to the commitment level students have to the learning environment and the individual responsibility level they take for learning objectives. Engagement is a concept that expresses the degree to which students are engaged in academic content carried out in an educational setting. In addition, students' attention, curiosity, and interest in interaction related to learning goals are associated with engagement (Fredricks et al., 2004). Active engagement refers to meaningful engagement in learning goals through action-oriented behaviours such as asking questions, discussing, and collaborating (Christenson et al., 2012). With these qualities, engagement is considered a critical component of effective and meaningful learning (Reeve, 2013).

Student engagement can be identified as a concept that reflects students' psychological attitudes towards a course (Cevikbas & Kaiser, 2022). It is a comprehensive concept that reflects students' emotional, behavioural, and cognitive endeavours in the learning process (Reinke et al., 2022). In this context, engagement is associated with students actively participating in learning processes and developing a sense of belonging towards learning objectives (Reschly & Christenson, 2022). As engagement is a concept that directly influences student motivation towards learning processes, its impact on academic achievement can be significant (Jansen et al., 2023). Engagement, which is directly linked to the academic performance factor in students' academic lives, is shaped by the interaction of factors such as individual characteristics, family, school, and the social environment (Reinke et al., 2022; Reschly & Christenson, 2022). In this context, engagement can be considered a key component that addresses both the academic and social aspects of learning environments.

The primary goal of engagement is to improve learning performance by helping students actively construct knowledge (Christenson et al., 2012; Skinner et al., 2009). In educational settings, active engagement is widely preferred because it is compatible with constructivist and student-centred pedagogies. Techniques such as collaborative learning, problem-based tasks, and technology-supported interactions are widely used to encourage engagement (Prince, 2004). These techniques, which aim to increase engagement, generally work by creating meaningful learning experiences that orient students to interact with their teachers and peers. As students engage in learning environments, their intrinsic motivation may increase, leading to more effective learning (Schunk et al., 2008). Ultimately, active engagement encourages deep learning by transforming students from passive listeners to active participants who construct and make sense of knowledge (Skinner et al., 2009).

Related Work

This section presents recent studies that examine the GFL approach in the context of self-efficacy and engagement. The studies listed in Table 1 are classified and presented in the context of self-efficacy and engagement.

Table 1. Current studies related to gamified flipped learning.

Author(s)	Gamification Platform	Research Aim Category	Conclusion
Ahmed and Asiksoy (2021)	Digital (Intangible)	Self-Efficacy	It was determined that GFL positively influenced students' innovation skills but had no impact on their self-efficacy beliefs. Additionally, it was noted that students held a favourable opinion of GFL.
Ghafouri et al. (2024)	Digital (Intangible)	Self-Efficacy	Research shows that the use of GFL significantly enhances students' ability to assess patient health. Additionally, student satisfaction with GFL is notably high.
Ng and Lo (2023)	Digital (Intangible)	Engagement	It has been determined that GFL significantly contributes to student engagement and sustainable learning performance, and students hold a positive view of the process.
Xiao and Hew (2024)	Hybrid (Tangible and Intangible)	Engagement	Students in the GFL group, who received tangible rewards, performed significantly better in intrinsic motivation, engagement, and learning performance.
Yllana-Prieto et al. (2021)	Digital (Intangible)	Self-Efficacy	It was concluded that there was an improvement in students' attitudes and self-efficacy levels after using GFL.
Zainuddin et al. (2022)	Digital (Intangible)	Engagement	It was determined that GFL has positively impacted student engagement levels.

IOJPE

ISSN: 1300 – 915X
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International Online Journal of Primary Education 2026, volume 15, issue 1

Table 1 shows studies that examine the GFL approach in terms of self-efficacy and engagement concepts. These studies, which utilise various elements of gamification, primarily report positive results. Although the existing research successfully examines the impact of the GFL approach, it includes limitations in terms of the platform and application method of gamification. However, a deeper examination of the literature reveals several significant limitations. Firstly, most studies conceptualise gamification as a uniform instructional approach without distinguishing between different gamification elements. In particular, the distinction between tangible and intangible gamification has largely been insufficiently researched. Secondly, while many studies focus predominantly on the digital or non-physical designs of gamification elements such as points, badges, and leaderboards, relatively few investigate the pedagogical effects of tangible gamification elements in educational settings. Thirdly, existing research tends to focus on specific gamification elements, such as reward and feedback systems, rather than examining different design structures for gamification in learning environments.

Among the limited number of studies addressing this distinction, Xiao and Hew (2024) differentiate between tangible and intangible gamification elements. However, their focus lies more on reward-based mechanisms rather than a comprehensive comparison of gamification structures. This highlights the need to investigate the differing effects of tangible and intangible gamification on educational outcomes.

In consideration of these limitations, this study aims to provide a more comprehensive perspective by systematically comparing tangible and intangible gamification within a flipped learning environment. It focuses not only on intangible gamification elements but also on the wider design of gamified learning experiences. This study aims to contribute to the literature by providing a deeper understanding of how gamification elements, particularly when embodied in learning environments, affect students' self-efficacy and engagement.

METHOD

Research Model

One of the matching-only research models, the pretest-posttest control group model, was chosen as the research model for this study. This model is used in experimental research to test and compare the effects of an application. This research model was chosen as the research model because it allows for the comparison of data collected from matched groups based on a specific factor (Fraenkel et al., 2011). In this model, the research process begins with dividing participants into matched groups. Following this stage, pretest applications were conducted. The research process was completed with posttest applications after the experimental procedure. The process related to the research model is outlined in Table 2.

Table 2. The matching-only pretest-posttest control group design.

Group		Pretest	Process	Posttest
E1	M	A1	X	A4
E2	M	A2	Y	A5
C	M	A3	Z	A6

E1: GFL intangible experimental group
E2: GFL tangible experimental group
C: Control group
M: Matching based on mathematics academic accomplishment
A1: Intangible experimental group pretest application
A2: Tangible experimental group pretest application
A3: Control group pretest application
X: GFL is supported by intangible gamification
Y: GFL is supported by tangible gamification
Z: Traditional learning approach
A4: Intangible experimental group posttest application
A5: Tangible experimental group posttest application
A6: Control group posttest application

Table 2 shows the quasi-experimental model of the study. The entire experimental procedure was performed within the extent of the fifth-grade mathematics course, which consisted of five lessons per week, each lasting 40 minutes. The experimental and control groups (E1, E2, and C) were matched (M) according to their academic accomplishment in mathematics prior to the study. The pursuit of this matching was to prevent the possible effect of self-confidence derived from academic achievement on the dependent variables of the study, MLSB and engagement.

Following the matching process, pretests of the MLSB and engagement scales were performed for all three groups. After the pretests, the experimental process was initiated. In all three groups, the mathematics teaching process was carried out by following the Fifth-Grade Mathematics Curriculum, which includes the dependent variables of the study, mathematical literacy skills (Milli Eğitim Bakanlığı [Ministry of National Education] [MoNE], 2018). In addition, the teaching process of the experimental groups differed from that of the control group in that gamification applications and the flipped learning approach supported it. The control group teaching process was accomplished using the traditional teaching process (Z).

Since this study investigated the effects of different types of gamification on the dependent variables, the research model was designed with two experimental groups. In accordance with this objective, the teaching process of the experimental groups was differentiated in terms of the type of gamification applications. In addition to the flipped learning approach design, the mathematics course teaching procedure was enhanced by intangible gamification elements (X) in the first experimental group (E1) and tangible gamification elements (Y) in the second experimental group (E2). The experimental process, which was implemented after the pretests, lasted a total of 11 weeks, consisting of a pilot week and 10 implementation weeks. The pilot week was conducted to increase students' familiarity with the process. Data from the pilot week were not incorporated into the research data set. The experimental procedure was completed after the posttest applications.

Study Group and Ethics

The study group comprises three classes with a total of 69 students in the fifth-grade at a public school in Türkiye during the 2022-2023 academic year. The classes were matched to be equivalent in terms of academic accomplishment in mathematics. One of the three classes was randomly selected as the experimental group, in which the flipped learning process supported by tangible and intangible gamification elements was implemented. The other class served as the control group, in which the traditional teaching method was used. The research was conducted over a total of 11 weeks, including a pilot week and 10 implementation weeks, within the extent of the mathematics course. All students in the class participated fully in the 10-week implementation process, and no student preferred to leave the implementation until the end of the research period. The study group's demographic characteristics are shown in Table 3.

Table 3. Study group demographic characteristics.

Group	Female	Male	Sum
Intangible Element Group (E1)	12 (52.17%)	11 (47.83%)	23 (100%)
Tangible Element Group (E2)	12 (52.17%)	11 (47.83%)	23 (100%)
Control Group (C)	13 (56.52%)	10 (43.48%)	23 (100%)
Sum	37 (53.62%)	32 (46.38%)	69 (100%)

Table 3 shows the study group characteristics. Each group in the study was represented by 23 students aged 10. The intangible element group (n=23) consisted of 12 females (52.17%) and 11 males (47.83%). The tangible element group (n=23) is similar to the intangible element group, consisting of 12 females (52.17%) and 11 males (47.83%). The control group (n=23) consists of 13 females (56.52%) and 10 males (43.48%). The study group comprises 69 students, including 37 females (53.62%) and 32 males (46.37%). Compared to older students, 10-year-old students are more prone to games and game culture due to their age level (Boyd & Bee, 2014). Since this study is related to game philosophy and culture, it was considered that the fifth-grade would be more suitable for the study group.

The necessary conditions related to research ethics were provided before the study (Lodico et al., 2010). Written permissions were obtained from the relevant institutions prior to the study. Student participation in the research process was entirely voluntary. The written permissions were obtained from parents since the students were under 18 years of age. The students and parents were informed in detail about the process and reminded that they had the right to leave the process at any time. The students and parents were informed that the data collected would only be utilised for this study and that personal information would remain confidential.

Data Collection

Study data were gathered utilising a scale method. Two five-point Likert-type scales were used for the dependent variables of the study. In order to determine students' MLSB, the mathematical literacy self-efficacy scale developed by Baypınar and Tarım (2019) to determine students' self-efficacy beliefs regarding their mathematical literacy skills was used in the study. The scale, developed with the engagement of 1124 students, was designed using a five-point Likert scale. The scale, consisting of 30 items, includes the mathematical skill dimension (items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15), the personal experience dimension (items 16, 17, 18, 19, 20, and 21), scientific modelling dimension (items 22, 23, 24, and 25), and social context dimension (items 26, 27, 28, 29, and 30). The Cronbach's Alpha reliability coefficient of the scale, which explains 48.34% of the variance, was calculated as .92. The Cronbach's alpha reliability coefficients for the dimensions of the scale were determined as .90 for the mathematical skill dimension, .75 for the personal experience dimension, .78 for the scientific modelling dimension, and .81 for the social context dimension. The scale was associated with MLSB, one of the dependent variables of this study. It was referred to as the MLSB scale throughout the study.

The engagement scale, developed by Wang, Bergin, and Bergin (2014) and adapted to Turkish culture by Sever (2014), was used in this study to determine students' levels of engagement. The scale, which comprises 23 items on a five-point likert scale, includes the affective engagement dimension (items 1, 2, 3, 4, 5, and 6), the behavioural engagement-compliance dimension (items 7, 8, 9, and 10), the behavioural engagement-effortful classroom participation dimension (items 11, 12, and 13), cognitive engagement dimension (items 14, 15, 16, 17, 18, 19, and 20), and disengagement dimension (items 21, 22, and 23). The Cronbach's Alpha reliability coefficient of the scale, which explains 65.32% of the variance, was calculated as .93. The Cronbach's alpha reliability coefficients for the scale's dimensions were determined as .87 for the affective engagement dimension, .82 for the behavioural engagement-compliance dimension, .74 for the behavioural engagement-effortful classroom participation, .89 for the cognitive engagement dimension, and .69 for the disengagement dimension.

Implementation

This research was performed within the extent of a primary school mathematics course consisting of five lessons per week. The teaching process for all groups was planned and implemented in line with the objectives of the Fifth-Grade Mathematics Curriculum (MoNE, 2018). The mathematics topics covered in the research implementation process and the time allocated to them were determined in accordance with this curriculum. Table 4 shows the topics covered in the mathematics lessons during the implementation period of the study.

Table 4. Mathematics course topics during the implementation process.

Week	Topic	Time
1 (Pilot Test Week)	Basic Geometric Concepts	200 minutes
2	Basic Geometric Concepts	200 minutes
3	Basic Geometric Concepts	200 minutes
4	Triangles and Quadrilaterals	200 minutes

Table 4 (Continued). Mathematics course topics during the implementation process.

Week	Topic	Time
5	Triangles and Quadrilaterals	200 minutes
6	Triangles and Quadrilaterals	200 minutes
7	Data Collection and Analysis	200 minutes
8	Measurement: Length and Time	200 minutes
9	Measurement: Length and Time	200 minutes
10	Measurement: Area	200 minutes
11	Measurement: Area	200 minutes

The mathematics lessons relating to the study implementation process are shown in Table 4. Throughout the process, all pre-class (instructional videos, weekly tasks, mini-tests) and in-class activities were designed weekly in accordance with the learning objectives for these topics. For example, all activities related to Week 4 were designed in accordance with the learning objectives for the "Triangles and Quadrilaterals" topic. Although the educational content for both the experimental (E1 and E2) and control (C) groups was organised around these topics, the way in which it was implemented differed. The teaching process for the control group was conducted using a traditional teaching approach that did not include any elements of flipped learning or gamification. In the experimental groups, the teaching process was carried out using the flipped learning approach. Additionally, the instruction strategy for both experimental groups was enhanced with gamification elements. Also, the teaching strategy in both experimental groups differs in terms of the gamification platform. The intangibly designed gamification elements supported the teaching process of the intangible element experimental group (E1) via an intangible platform. In contrast, the gamification elements of the tangible element experimental group (E2) were designed using traditional pen-and-paper applications and presented via a platform created using this method. This section of the study outlines the applications implemented to support the teaching processes for the study group. Then, the differences between the flipped learning and gamification applications in the experimental and control groups were discussed.

The flipped learning environment and intangible gamification elements of the study were provided to students through MOODLE. MOODLE is an open-source learning management system. The name MOODLE is an acronym for "Modular Object-Oriented Dynamic Learning Environment". MOODLE is a popular learning management system that enables educational institutions and teachers to create, deliver, manage, and evaluate online education (Buchner, 2022; Cole & Foster, 2007). Thanks to its content focused on the protection of personal information, MOODLE has gained widespread use worldwide (Conde et al., 2010). Its free availability, user-friendly interface, customisable features through downloadable plugins, and flexible design structure that can be adapted to specific needs make it an advantageous platform for creating learning environments (Costello, 2013). Due to its flexible design, it accommodates the inclusion of flipped learning elements and gamification elements. Gamification elements of this research were explicitly designed for the study and with defined usage objectives in the learning management system. With these advantageous aspects, MOODLE was considered suitable for the study and was chosen as the teaching management system for the research.

Student registration in the system was carried out by the researcher. Following this stage, the process of creating classes for tangible and intangible study groups within the system was initiated. Students were assigned to their respective classes through the system. Login credentials for accessing the system were created individually for each student. Usernames (IDs) and passwords for accessing the system were distributed to the students. Following this phase, sections were created on the system where instructional videos, instructional presentations, mini-tests, weekly tasks, and answer keys for weekly tasks could be uploaded. Unlike the tangible element group, a section was created in the intangible element group's class on the system where intangible gamification elements could be placed. A video guiding the system's operation was prepared by the researcher and placed in the relevant section of the system in both MOODLE classrooms. After the announcements and academic calendar sections were also created, the general setup process was completed with the design of discussion areas specific to both classes.

After the general setup phase, the pilot week phase was initiated. The purpose of the pilot week was to increase students' familiarity with the system and identify any shortcomings in the system. The system was improved and made more suitable based on student suggestions and the experience gained. This research aims to examine the effect of GFL on MLSB and engagement. The content of the experimental applications was determined in line with this aim.

Flipped learning process

The flipped learning model used in this study was adapted from the 10-step flipped learning model proposed by Lo et al. (2017). In this model, the flipped learning stages are divided into two main sections: out-of-class and in-class. The purpose of the model is to guide the flipped learning approach to be applied in the mathematics teaching process. Since the specified stages were primarily developed for the mathematics teaching process, this model was considered appropriate for the research and was chosen as the flipped learning model.

Several special adjustments were made to the model proposed by Lo et al. (2017) to suit the purpose of the research. In this study, the proposed stages were revised to suit the content of experimental applications better, as contemporary learning methods, techniques, and gamification elements support the flipped learning model. Figure 1 shows the flipped learning model used in the study.

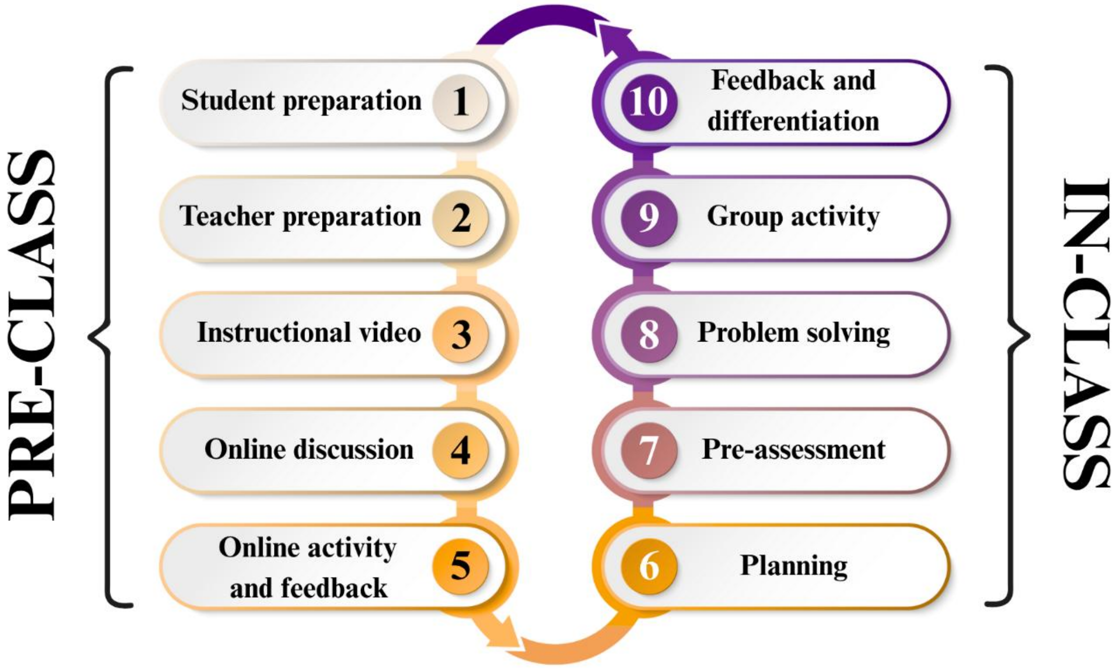

Figure 1. The flipped learning model of the research.

Figure 1 shows the study's flipped learning approach model. The model is divided into two main categories: pre-class and in-class. Each category consists of five stages, and the model comprises 10 steps. The first main category of the process, the pre-class process, begins with a preparation phase for students and teachers. This stage is followed by the instructional video stage. After the video phase, there is an online discussion section where discussions related to the current topic are held. The pre-class teaching process is completed with the online activity and feedback section.

The planning stage, in which the necessary procedures are implemented based on student experiences and feedback related to the pre-class teaching process, constitutes the first stage of the in-class process in the model. Following this stage, a mini pre-assessment was conducted to test students' prior learning related to the pre-class process. Student-centred learning practices, such as problem-solving and group discussions, were performed based on the results of the pre-assessment stage. Following this stage, the classroom teaching process of the model was completed with the feedback and differentiation phase, where necessary feedback, differentiation, and enrichment activities were provided.

The model-based applications started with the first phase at the beginning of each implementation week and were completed with the tenth phase. This process was repeated as a cycle from the beginning to the end of the implementation process. The flipped learning process is the same for both experimental groups and was implemented through MOODLE. The design of the pre-class teaching content and instructional videos was based on Mayer's (2009) multimedia design principles. The activities of the in-class teaching process were designed based on the flipped teaching process model proposed by Talbert (2017).

Gamification process

Five gamification elements were selected for the study: Collection Table, Avatar, Badge, Progress Bar, and Level. These elements are among the most preferred and most positively reported elements for gamification in learning environments (Behl et al., 2022; Ekici, 2021). The element designs and definitions were based on the Pyramidal Gamification Design Model proposed by Werbach and Hunter (2012). Since the aim of the study also included comparing gamification elements in tangible and intangible concepts, it was critical that the elements included in the process could be designed in both ways. The five gamification elements mentioned above were considered appropriate for the study and were chosen because they could be designed in both tangible and intangible forms.

In this study, the elements were designed to have the same function in both designs so that tangible and intangible elements could be effectively compared. In addition, it was ensured that the tangible elements had the same visual form as the intangible elements as much as possible. The intangible experiment group's flipped learning process was supported by gamification elements designed intangibly and presented via MOODLE. The tangible experiment group's flipped learning process was supported by gamification elements designed tangibly using traditional pen-and-paper methods. Below are descriptions of the tangible and intangible gamification elements used in the research, along with images illustrating their use in the application process. Figure 2 shows the intangible version of the research's gamification model, and Figure 3 shows the tangible version.

Figure 2. Intangible collection table and element usage.

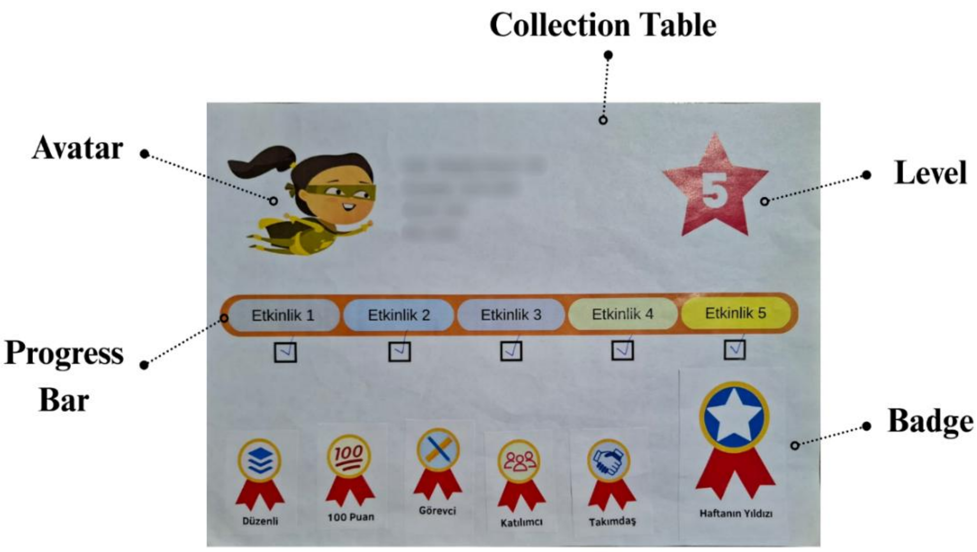

Figure 3. Tangible collection table and element usage.

Figures 2 and 3 contain visuals related to the design of the tangible and intangible gamification models of the study. The gamification elements preferred to be used in the study are included in both models. The definitions and roles of the gamification elements utilised in the study are as follows.

- Collection Table: A personal file element in which students can store the elements they collect throughout the process. The collection table was designed to contain gamification elements in both experimental groups.
- Avatar: An element of the visual content that students have chosen to represent themselves in the process. In both groups, students chose their avatars. Students were allowed to make changes to their avatars throughout the process.
- Badge: This is a visual element that students earn based on their achievements during the process. The visuals of the badges were specially designed for the study to be consistent with the tasks in the process. The visuals and functions of the badges used in the research process are shown in Figure 4.

Figure 4. Research badge set.

IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education 2026, volume 15, issue 1

Figure 4 shows the images and functions of badges explicitly designed for the study. The badges were designed to be compatible with the flipped learning approach of the study. The first four badges were designed for the pre-class process of flipped learning, while the other two badges were designed for in-class process learning activities.

- Progress Bar: This element visually demonstrates the degree of completion of the students. The progress bar used in the intangible group automatically advanced according to the students' completion percentages. The teacher manually advanced the progress bar used in the tangible group according to the students' completion status.
- Level: This element indicates the expertise level of students in the gamification process. There are 10 levels in both experimental groups. Each level was used to represent the week in progress. Students who had tasks or activities missing for the week in progress were advanced to the level of the week in progress when they completed the support activities.

One of the main goals of gamification is to improve individuals' sense of belonging to their environment (Manzano-Leon et al., 2021; Werbach & Hunter, 2012). In this regard, the element design was created so that every student could engage in the process, gain something meaningful, contribute their own insights, and find opportunities for self-expression. With this in mind, it is expected to improve students' sense of belonging during the implementation period and thus increase their self-efficacy and engagement levels.

Data Analysis

The data analysis of the study was performed using the SPSS software package. The statistical significance level for all analyses was set at $p<.05$. Normality analyses were classified according to the dimensions of the scales used in the study and the pretest and posttest implementations. As a result of the analysis, it was determined that the skewness and kurtosis values of the mean scores of the dimensions of the MLSB scale and the engagement scale were between -3 and +3. In this regard, it was determined that the data set showed a normal distribution (Hopkins & Weeks, 1990; Kline, 2023).

In quasi-experimental studies, it is necessary to evaluate whether the experimental and control groups are at the same level in terms of the dependent variable before the experimental procedures. It is stated that the type of analysis to be performed should be decided based on these evaluations (Fraenkel et al., 2011). In this context, Analysis of Variance (ANOVA) was performed to determine the level of statistical difference between the study groups in terms of the mean scores of the pretest applications of the MLSB and engagement scales, which are the data collection tools of the study. The ANOVA results for the MLSB and engagement scales pretest applications are presented in Table 5.

Table 5. ANOVA results for the MLSB and engagement scale pretest values.

Scale	Dimension	F	p
Mathematical Literacy Self-Efficacy Beliefs	Mathematical Skill	2.83	.06
	Personal Experience	6.60	.00*
	Scientific Modelling	.31	.73
	Social Context	.06	.93
	Scale Overall	2.53	.08
Classroom Engagement	Affective Engagement	1.27	.28
	Behavioural Engagement-Compliance	.07	.92
	Behavioural Engagement-Effortful Classroom Participation	.21	.80
	Cognitive Engagement	1.34	.26
	Disengagement	2.10	.13
	Scale Overall	1.45	.24

*p<.05

Table 5 shows the ANOVA values obtained for the pretest applications of the MLSB and engagement scales. MLSB scale mathematical skill (F=2.83; p=.06>.05), scientific modelling (F=.31; p=.73>.05), social context (F=.06; p=.93>.05), and scale overall (F=2.53; p=.08>. 05) dimensions. However, a statistically significant difference was found in the pretest mean scores for the personal experience dimension (F=6.60; p=.00<.05). When Table 5 is examined, the affective engagement (F=1.27; p=.28>.05), behavioural engagement-compliance (F=.07; p=.92>.05), behavioural engagement-effortful classroom participation (F=.21; p=.80>.05), cognitive engagement (F=1.34; p=.26>.05), disengagement (F=2.10; p=.13>.05), and scale overall (F=1.45; p=.24>.05) dimensions of the pretest mean scores not show a statistically significant difference between the intangible element, tangible element, and control groups that formed the study group.

In this regard, the analysis of data related to the Personal Experience Dimension (PED), which is a dimension of the MLSB scale, was performed using covariance analysis (ANCOVA). This analysis method aims to compare the means of different groups by controlling the effects of one or more continuous covariates (Büyüköztürk, 1998). Thus, the statistical power of the measurements increases and the bias that arises from the standard variable decreases (Aldrich & Cunningham, 2016). Data analyses for all dimensions of the engagement scale and all dimensions of the MLSB scale except for the PED were performed using ANOVA.

RESULTS

This part of the study presents the results of the analyses performed on the data obtained from the scales. The results are classified as MLSB and engagement and are presented under the subheadings created for this purpose.

Mathematical Literacy Self-Efficacy Beliefs Results

The ANOVA results obtained from the pretest and posttest mean scores of the MLSB scale are shown in Table 6.

Table 6. One-way ANOVA results for the MLSB scale mean scores.

Dimension	F	p
Mathematical Skill	.02	.97
Scientific Modelling	.14	.86
Social Context	.40	.66
Scale Overall	.09	.91

Table 6 shows the ANOVA results for the MLSB scale data. No statistical difference was found between the pretest and posttest mean scores for the scale's mathematical skill (F=.02; p=.97>.05), scientific modelling (F=.14; p=.86>.05), social context (F=.40; p=.66>.05), and scale overall (F=.09; p=.91>.05) dimensions. Analyses of the PED were conducted using ANCOVA because the ANOVA results for the groups' pretest mean scores indicated a statistical difference.

In addition to the data set being normally distributed, the homogeneity of distributions is one of the assumptions of ANCOVA (Taşpınar, 2017). After determining that the data set was normally distributed, the homogeneity assumption was tested using the Levene Test. Table 7 shows the test results.

Table 7. Levene homogeneity test results.

F	df1	df2	p
.25	2	66	.77

Table 7 contains the values of the homogeneity test performed with the Levene test. Upon examining the table, a significance level of .77 was determined (F=.25; p=.77>.05). Since no statistical difference was found between the variances, it was determined that the data distribution was homogeneous, and it was concluded that this assumption of ANCOVA was met. Another assumption of ANCOVA is the assumption of homogeneity of regression slopes (Taşpınar, 2017). The ANOVA method was used to test this assumption. Table 8 shows the analysis results.

Table 8. Homogeneity of regression slopes.

Source	Sum of Squares	df	Mean Square	F	p
Group	3.14	2	1.57	2.01	.14
PED	1.74	1	1.74	2.23	.14
Group * PED	1.32	2	.66	.84	.43
Sum	67.74	68			

*Control Variable: PED pretest mean scores
*Dependent Variable: Personal experience posttest mean scores

Table 8 shows the ANOVA values obtained for testing the homogeneity of regression line slopes. The significance level value of .43 in the Table 8 indicates that there is no difference between the slopes of the regression lines. In other words, it was determined that the pretest scores for this dimension in the study groups did not have a statistically significant effect on the posttest mean scores of the PED (F=.84; p=.43>.05). After this condition was also met, it was concluded that the necessary assumptions for ANCOVA were met.

The first step in ANCOVA is to control for the covariate and determine the estimated mean scores for the dependent variable (Taşpınar, 2017). In this regard, the pretest mean scores for the PED were controlled for, and the estimated means for the posttest mean scores were determined. Table 9 contains these adjusted mean values.

Table 9. Estimated marginal means.

Grup	N	Mean	Estimated Marginal Means
Intangible Element Group (E1)	23	3.55	3.57
Tangible Element Group (E2)	23	3.55	3.60
Control Group (C)	23	2.70	2.61

Table 9 shows descriptive statistics for the ANCOVA. In this regard, estimated means were calculated for the final tests of the study groups, the intangible element (3.57), tangible element (3.60), and control (2.61) groups. The one-way ANCOVA was conducted to determine whether the differences between the estimated mean scores of the groups were statistically significant (Büyüköztürk, 2018). The results obtained from the analysis are shown in Table 10.

Table 10. One-way ANCOVA results.

Source	Sum of Squares	df	Mean Squares	F	p	Partial Eta Squared
PED	1.28	1	1.28	1.65	.20	.02
Group	12.22	2	6.11	7.86	.00	.19
Error	50.53	65	.77			
Corrected Total	62.84	68				

Table 10 shows the results of the one-way ANCOVA. When the values in Table 10 are examined, the significance level value related to the differences arising from the study groups is calculated as .00. In this regard, when the pretest mean scores for the PED of the MLSB scale were controlled, it was concluded that the posttest mean scores differed statistically according to the groups (F=7.86; p=.00<.05). In order to determine the level of this statistically significant difference, the effect size value for the estimated means was examined. Since the estimated effect size was .19, it was concluded that the types of gamifications used in the study (tangible and intangible) had a high level of effect (>.14) on the PED of MLSB (Taşpınar, 2017).

The Bonferroni Test was used to determine which group or groups these statistically significant differences favoured. The Bonferroni Test is a comparison test that allows for multiple comparisons in

ANCOVA (Büyüköztürk, 2018; Taşpınar, 2017). The results of this test showed that the intangible element (3.57) and tangible element (3.60) groups differed significantly from the control group mean (2.61), while there was no difference between the mean scores for the tangible and intangible element groups. In other words, the GFL applied in the experimental groups positively affected students' personal experiences with MLSB. However, the type of gamification used (tangible and intangible) did not result in a statistically significant difference.

Engagement Results

The ANOVA results for the mean scores of the pretest and posttest applications of the course engagement scale are shown in Table 11.

Table 11. One-way ANOVA results for course engagement scale mean scores.

Dimension	F	p
Affective Engagement	.26	.76
Behavioural Engagement-Compliance	.23	.79
Behavioural Engagement-Effortful Classroom Participation	.18	.83
Cognitive Engagement	.36	.69
Disengagement	1.72	.18
Scale Overall	.42	.65

Table 11 shows the results of the ANOVA conducted on the data obtained from the engagement scale. The scale's affective engagement ($F=.26$; $p=.76>.05$), behavioural engagement-compliance ($F=.23$; $p=.79>.05$), behavioural engagement-effortful classroom participation ($F=.18$; $p=.83>.05$), cognitive engagement ($F=.36$; $p=.69>.05$), disengagement ($F=1.72$; $p=.18>.05$), and scale overall ($F=.42$; $p=.65>.05$) dimensions.

DISCUSSION, CONCLUSION, and RECOMMENDATIONS

Gamification, whose primary goal is to increase individuals' motivation in their context, is defined as the integration of game design elements into non-game contexts (Deterding et al., 2011). The uncertainty arising from the application platforms of gamification, which is increasingly gaining prominence in contemporary educational technology literature, is noteworthy. The present study, which aims to address this uncertainty, focuses on two different approaches to gamification: tangible and intangible. The research was established based on the idea that, when designed with the characteristics of the study group in mind, tangible gamification can be as successful as intangible counterparts in learning environments. This research investigates the extent to which gamification, applied in different approaches, affects students' MLSB and engagement levels in flipped learning environments. The research results show that the flipped learning approach supported by tangible or intangible gamification elements positively affects primary school students' personal experiences with MLSB. In addition, it has been determined that the current application has no effect on students' engagement levels in the course. Based on this, this study presents a design model for the use of tangible and intangible gamification in flipped learning.

Gamification, which is frequently used to overcome motivation and engagement problems in flipped learning environments, is underlined to have strong potential due to its various elements (Candel et al., 2024; Do et al., 2023; Huang et al., 2019). Gamification, which can be incorporated into flipped learning environments through various platforms, is shown to be a popular method preferred by educators (Yu & Yu, 2024). The relevant literature includes studies evaluating gamification in flipped learning. Current studies examine the gamification effect on self-efficacy and engagement variables. In these studies, gamification has been tested to improve self-efficacy (Ahmed & Asiksoy, 2021; Yllana-Prieto et al., 2021) and engagement (Ng & Lo, 2023; Xiao & Hew, 2024; Zainuddin et al., 2022), and positive results have been reported. Although these current studies have successfully tested gamification in a flipped learning environment in the context of educational goals, the limitations of application platforms are remarkable. Among these studies emphasising the importance of educational gamification, it can be seen that only Xiao and Hew (2024) have preferred to distinguish between tangible and intangible gamification. Although the study reported positive results from applying gamification rewards in both tangible and intangible forms, it seems that the study's focus was on the reward element only (Xiao & Hew, 2024). Focusing on the current limitations in recent studies, this research aims to determine the effect of tangible and intangible gamification in a flipped learning environment, delivering a more profound perspective on the differentiation of gamification applications.

The findings of this study should be considered in light of the current limitations in the literature on gamification in flipped learning environments. While previous research has generally reported the positive effects of gamification on variables such as self-efficacy and student engagement, most of these studies treat gamification as a uniform instructional approach and focus predominantly on digital or non-tangible forms of gamification. In particular, the distinction between tangible and intangible gamification has received limited empirical attention. Furthermore, how different gamification designs might lead to learning outcomes has rarely been examined.

In this context, the present results contribute to the literature by offering a more detailed perspective on gamification design. The absence of significant differences in the dimensions of the MLSB beyond personal experience (mathematical skill, scientific modelling, and social context) and in engagement, whether tangible or intangible, suggests that merely integrating gamification elements into the learning environment may not be sufficient to influence complex concepts such as engagement. Instead, the effectiveness of gamification may depend not merely on the forms of these elements, but on how they are pedagogically designed and aligned with learning processes. This finding also emphasises the need to move beyond element-based comparisons in gamification research and to focus more on the instructional design and contextual implementation of gamified learning environments.

This study provides critical implications for primary education as well. As primary school students are highly responsive to interactive and activity-based learning environments, integrating gamification into the flipped learning model can offer opportunities to foster MLSB and active engagement. However, the results indicate that the effectiveness of such approaches depends not only on the presence of gamification elements, but also on how these elements are designed from a pedagogical perspective and how they are implemented in the classroom.

Pedagogical Implications and Recommendations

This research provides considerable pedagogical contributions to the relevant literature by advancing the understanding of the use of gamification in flipped learning environments. Present research is the first study to examine the tangible and intangible gamification-enhanced flipped learning approach concerning MLSB and course engagement contexts. The study tested the effect of gamification elements explicitly designed for the study group, implemented through tangible and intangible platforms in a flipped learning environment. The present research draws attention to a non-digital platform-based approach to gamification. In addition, it emphasises the importance of gamification designs being applicable in educational environments with a digital and traditional pen-and-paper approach. This approach contributes to the applicability of educational gamification by paving the way for more personalised gamification designs. This study's results indicate that, within the context of personal experience, tangible gamification elements are as effective as their intangible counterparts in flipped learning environments. The tangible nature of the gamification elements may have encouraged students to interact with them more frequently. This characteristic has led to the idea that tangible gamification elements may have replaced the appeal of intangible gamification elements for students in this age group (10 years old). It is therefore estimated that tangible elements may have contributed to this research finding by providing students with an extraordinary personal experience.

The study found that the GFL approach did not affect students' MLSB in terms of mathematical skills, scientific modelling, and social context dimensions. However, in terms of the personal experience aspect, both tangible and intangible gamification applications were found to have a positive effect. This result of the study is consistent with the existing literature (Ghafouri et al., 2024; Yllana-Prieto et al., 2021). Personal experience refers to students' individual experiences in the context of their MLSB. This result implies that tangible and intangible gamification applications positively affect students' self-efficacy beliefs acquired from experiences related to mathematical skills. In the study, gamification elements designed tangibly or intangibly were student-centred, and their compatibility with learning content was ensured. It is considered that this situation may have positively influenced students' personal experiences regarding their MLSB by directing their interest towards the learning process. This situation shows that tangible and intangible gamification applications can be used to enrich students' individual experiences in a flipped learning environment. With this feature, gamification can assist in providing students with personalised experiences in mathematical skills in a flipped learning environment. In other words, the GFL approach can be an effective strategy in providing students with quality experiences related to learning goals. In addition, the research results indicate that the context of MLSB needs to be investigated more deeply in terms of its dimensions of mathematical skills, scientific modelling, and social context. There may be several reasons why this study's gamification designs did not result in a significant difference in these dimensions of MLSB. Given the multidimensional and comprehensive nature of MLSB, it is considered that the gamification designs incorporated in the present study may have been inadequate. In other words, the tangible and intangible gamification elements included in this study may not have been qualitatively and quantitatively sufficient in terms of developing a multidimensional concept such as MLSB in all its dimensions. It is estimated that applications which could be beneficial in terms of other dimensions of MLSB could be implemented by using more enriched tangible or intangible gamification designs, tailored to the needs and characteristics of the learning environments, by teachers and researchers.

This study found that the GFL approach did not affect the dimensions of student course engagement, affective engagement, behavioural engagement-compliance, behavioural engagement-effortful classroom participation, cognitive engagement, and disengagement. In other words, both tangible and intangible gamification elements were found to be insufficient in increasing students' engagement levels in the flipped learning environment. This result is inconsistent with the existing literature, which emphasises that the GFL approach encourages student engagement (Ng & Lo, 2023; Xiao & Hew, 2024; Zainuddin et al., 2022). The fact that current applications are ineffective in increasing students' engagement levels stands out as an unexpected finding of the study. Considering that gamification has the potential to influence engagement motivation (Huang et al., 2026; Lo & Hew, 2020; Pan et al., 2026; Zou, 2020), this result can be considered surprising. It is speculated that the novelty effect is responsible for such a result. The novelty effect refers to the temporary increase in personal motivation when faced with something new, which decreases over time as it becomes familiar (Clark, 1983). It is estimated that the tangible and intangible GFL applications implemented over a period of 11 weeks may have formed habits in students over time and thus may have brought their motivation to engagement in the course back to the initial level. Besides this, the concept of engagement is multifaceted in nature, encompassing behavioural, emotional, and cognitive dimensions (Reschly & Christenson, 2022). In this context, the GFL designs (tangible and intangible) employed in this study may not have been sufficient to develop this multifaceted concept. It is considered that more suitable applications for learning environments could be developed using GFL designs specifically tailored to each aspect of engagement. It is anticipated that such applications, if they are capable of addressing all aspects of engagement specifically, could positively influence student engagement in learning objectives. It is suggested that teachers focus on more personalised and process-renewed designs when incorporating tangible and intangible gamification applications into the flipped learning environment, which may help overcome engagement problems. It is thought that the application design of the current study should be supported by more gamification elements that encourage engagement. It is believed that future studies focusing on more innovative gamification approaches that emphasise active student engagement could contribute to the literature on GFL in the context of educational technologies.

Therefore, this study shows that tangible gamification elements designed to suit the characteristics of the study group are as successful as intangible gamification in improving students' personal experiences regarding their MLSB. The study emphasises the importance of gamification being usable in a flipped learning environment with a non-digital approach. In other words, the present study underscores that gamification can be used in learning environments with tangible designs as well as intangible ones. The research also provides important insights into how gamification can be embodied and used in learning environments. The study highlights that more effective designs can be created to improve students' active engagement in the flipped learning process. It emphasises that research on the tangible, intangible, and hybrid designs of GFL can contribute to the relevant literature if their gamification model is designed according to student preferences. Consequently, this study highlights the significance of various design approaches for gamification, serving as a guide for aligning gamification elements with learning objectives.

Validity and Limitations

The present study has several validity threats and limitations. The research was conducted using a quasi-experimental model. To prevent differences in self-confidence arising from students' previous mathematics accomplishments impacting the results, the study groups were made equivalent in terms of academic achievement in mathematics. Although a random selection was made regarding which group would be the experimental group and which would be the control group, students were not randomly assigned to groups as in experimental models. Additionally, the study group students are all from the same school and live in the same neighbourhood. Therefore, when evaluating the research results for generalisability, it should be noted that regional and cultural differences may have influenced the findings.

The study group is limited to 69 students in the fifth-grade (10 years old) in Türkiye. It should not be overlooked that the method used in this study may not yield the same results in every age group. Present results should be evaluated carefully, as participant preferences for personalisation in gamification designs may vary according to age and educational level. Although the data showed a normal distribution, it should be noted that the study group was limited to 69 students. This situation may have made the results insufficient in terms of generalisability. The research lasted 11 weeks total, including the pilot test week. It should be considered that this period may have been insufficient to affect the dependent variables of the present research. Thus, the process of the experimental implementation may have affected the validity of the study, as it may have influenced the capacity to change the variables.

The gamification elements in the present study are limited to those selected from the Pyramidal Gamification Design Model proposed by Werbach and Hunter (2012) and adapted to the study. Considering that using other elements of the model or elements from other gamification models in a similar research context may produce different results. Additionally, the study was performed within the scope of a flipped mathematics course, alongside the existing curriculum. Gamification designs integrated into different learning techniques through other curricula may produce different results in a similar implementation. The validity threats and limitations mentioned above should be considered as they may affect the generalisability of the results.

Funding

No funding was received from any individual or institution for this research.

Ethics and Conflict of Interest

Ethical approval for the study was obtained from the Ethics Committee of Gazi University (dated 06.03.2023 and numbered E.603958) and the Governorship of Düzce (dated 13.04.2023 and numbered E-10240236-20-74353790). Canva design tools were used to develop gamification elements and research visuals. The authors would like to thank the Gazi University Academic Writing Application and Research Center for proofreading the manuscript. The authors declare that they have no conflicts of interest.

Author Contribution

This study is derived from the first author's doctoral dissertation entitled *"The Effect of the Gamification-Enhanced Flipped Learning Approach on Mathematical Literacy Self-Efficacy Beliefs and Engagement."* The second author supervised the research as the thesis advisor.

Data availability

The data that support the findings of this study are available on request from the corresponding author.

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