Jurnal Gantang *10*(2) (2025): 361-370

JURNAL GANTANG

e-ISSN: 2548-5547
p-ISSN: 2503-0671

http://ojs.umrah.ac.id/index.php/gantang/index

Enhancing learners' mathematics achievement by using a gamified flipped classroom instructional strategy

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Submission: September 25th 2025; Accepted: November 23rd 2025; Published: November 30th 2025
DOI: https://doi.org/10.31629/jg.v10i2.7674

Abstract

Flipped learning is an educational approach that inverts the traditional teaching pattern by giving pupils access to learning materials before class, while using classroom time to deepen their understanding. However, few studies investigate whether low-basic learners possess the readiness and digital literacy to benefit from this approach. Hence, this study examined the impact of implementing a Gamified Flipped Classroom Instructional Strategy on enhancing mathematics achievement among lower primary learners in Ilorin West Local Government Area of Kwara State, Nigeria. Employing the pre and posttest control group in line with a quasi-experimental design, 74 learners from two private primary schools participated in the research. This study employed three validated research instruments: the Mathematics Achievement Test (MAT), the Guide for Gamified Flipped Classroom Instructional Strategy (GGFCIS), and the Guide for Control Group (GCG). The MAT instrument demonstrated a reliability coefficient of 0.74 using the test-retest method. Two hypotheses were evaluated by using Analysis of Covariance (ANCOVA) at a 0.05 significance level. Results indicated a significant positive effect of the gamified flipped classroom instructional strategy on learners' academic achievement in mathematics. However, no significant interaction between treatment and gender was found. The study concluded that regardless of gender, the instructional strategy improved the academic achievement of lower basic learners in mathematics. The study recommended that primary school teachers undergo training in using the gamified flipped classroom instructional Strategy for teaching mathematics to lower basic primary learners, as it promotes academic success while encouraging parental involvement in learners' learning.

Keywords: gamified learning; flipped classroom; mathematics achievement; active learning

How to cite: Sulaimon, J. T., Manditereza, B., & Chamboko-Mpotaringa, M. (2025). Enhancing learners' mathematics achievement by using a gamified flipped classroom instructional strategy. *Jurnal Gantang, 10*(2), 361 – 370. https://doi.org/10.31629/jg.v10i2.7674

I. Introduction

Recent technological advancements have led to the creation of many online learning platforms to improve teaching and learning experiences, especially in the era of the fourth industrial revolution (4IR). Hence, active learning through technology has become increasingly popular (Sivananda & Aziz, 2021). One such approach is the flipped classroom technique, which comprises two key components: in-class

and out-of-class teaching and learning experiences (Aşıksoy, 2018). Both involve learners engaging in active activities such as problem-solving and in-depth discussions to enhance cognitive development. Learners can indulge in out-of-class activities by assessing content through online technology to familiarize themselves with topics in preparation for the following day's lessons. When learners become *a fait* with new knowledge, especially through online platforms, they become acquainted with it and employ it to fill gaps in their understanding, which leads to long-term retention of content (Hultén & Larsson, 2018). For instance, integrating gamification into flipped classrooms is a novel techno-pedagogy that fosters engaging, creative and successful learning experiences for learners (Desa & Halim, 2022; Ng & Lo, 2022a).

The Gamified Flipped Classroom Instructional Strategy is grounded on the Active Learning Theory and Intrinsic Motivation Theory. Based on the ideas of Dewey, who believes that children learn most effectively when they are actively engaged, reflecting, and actively experiencing the surrounding world (Dewey, 1938), the flipped model alters the acquisition of knowledge in learning to the home environment and uses classroom time to solve problems, explore, and engage in cooperation with other children. Gamification reinforces this process by leveraging learners' intrinsic motivation, their inherent interest in engaging in activities for enjoyment, personal satisfaction, and other intrinsic rewards (Deci & Ryan, 1985). Wang et al. (2022) argue that characteristics such as autonomy, competence, and social connection, which are central to Self-Determination Theory, contribute to maintaining learners' desire to engage with mathematical tasks and continue their work despite difficulties.

Numerous studies investigated the integration of gamification into flipped classroom environments across different contexts, including during the Covid-19 pandemic (Lestari & Noer, 2021; Ng & Lo, 2022b). This included its impact on performance and academic commitment to sustainable learning (Ng & Lo, 2022a), its effects on motivation and learning (Recabarren, Corvalán & Villegas, 2023) in different settings such as secondary education (Desa & Halim, 2022), health education (Chen, 2016) and teacher-training (Gómez-Carrasco, Monteagudo-Fernández, Moreno-Vera & Sainz-Gómez, 2020). Although these studies used the model and elicited positive outcomes for learners through active participation, motivation, social interaction, and self-managed learning skills, other studies reported negative outcomes (De-Marcos, Domínguez, Saenz-de-Navarrete & Pagés, 2014), while others showed inconclusive findings (Hew, Huang, Chu & Chiu, 2016).

Additionally, Güler, Kokoç & Bütüner (2023) investigated the integration of gamification into flipped classrooms and its effects on teaching and learning mathematics using a meta-thematic analysis of 69 articles. Although research indicates that flipped learning was primarily implemented in mathematics education for undergraduate learners, limited attention has been devoted to investigating the implications of the Gamified Flipped Classroom Instructional Strategy for enhancing mathematics achievement among lower-basic learners.

Notwithstanding the considerable evidence on gamified flipped classrooms at higher education levels, minimal empirical attention has been given to their possible effects among low-basic learners, particularly within the Nigerian basic education system. Studies assessing the effect of GFCI have been conducted among adolescents or adult learners who already have higher levels of digital literacy, self-regulation, and metacognitive skills, and therefore, their learning conditions are quite different from those of young children. As a result, it is still unclear whether gamified flipped learning is developmentally appropriate and instructionally viable for lower-basic pupils learning foundational mathematics in Nigeria, where the lack of home support, digital access, and low early-grade numeracy remain problems. The current research thus presents a significant

contribution by empirically assessing the effect of Gamified Flipped Classroom Instructional Strategy (GFCIS) on the mathematics performance of low-basic learners.

Literature Review

Gamification

Gamification is a teaching strategy incorporating game-like elements and mechanics into the learning process (Chamboko-Mpotaringa & Manditereza, 2023). Dichev and Dicheva (2017) define gamification as the addition of game-like elements to early childhood mobile apps to increase children's engagement and enjoyment in the learning process. Gamification's growing popularity is driven by its potential to boost motivation, drive behavioral change, foster healthy competition, and promote collaboration across contexts such as customer engagement, employee performance, and social loyalty (Dichev & Dicheva, 2017). In other words, gamification in early childhood education involves using game elements to enhance learning effectiveness and engagement. Since opportunities to overcome challenges and the rewards they offer encourage critical thinking, decision-making, and creative solutions, games like *badges and points* can enhance reading experiences that foster social interactions. Also, video game features like *quests* and *leaderboards* can enhance learning experiences. These instructional tools encourage a sense of ownership, clarify concepts, and strengthen skills, thus making early childhood education more engaging and effective. Moreover, the GFCIS is an approach projected to help learners stay engaged and motivated to accomplish their objectives (Elzecky, Elhabashy & Ali, 2022).

The Flipped Classroom

Flipped classrooms existed before technological advancements, but gained popularity as access to instructional resources became more commonplace. The flipped classroom model, initially known as the inverted classroom, was first introduced by Miami University professors in 2000 (Lage et al., 2000, cited in Yildirim & Kirayn, 2016). This strategy allows learners to access information outside class, thus providing time for higher-order cognitive activities. It has been practised in some disciplines for some time (Zou & Zhang, 2021) because it allows learners to learn new content at home and then master the material in school, thereby promoting learner-centered and collaborative learning endeavors. Although it offers flexibility, it creates a digital divide by relying on technology for learner preparation while increasing screen time. However, it is important to balance GFCIS benefits with practical considerations, such as resource availability.

Theoretical Framework

The Gamified Flipped Classroom

The Gamified Flipped Classroom method is a transformative approach to teaching mathematics by integrating games into the flipped classroom model. This approach aims to improve learners' understanding of mathematical concepts and academic performance. This research investigated the effectiveness of the GFCIS strategy to foster a deeper understanding of mathematical concepts to improve learners' overall performance in the subject. To thoroughly understand the Flipped Gamified Classroom, this study first described the concepts of gamification and flipped-classroom instruction intended to improve learner engagement and produce high-quality learning outcomes. That is, by combining the flipped classroom concept with gamification, this revolutionary teaching method aims to help students better understand mathematical concepts. This study also aimed to determine whether using this method would help learners grasp mathematical concepts more easily and deeply, enabling them to perform better on mathematics assessments.

Furthermore, GFCIS incorporates traditional teaching methods, technology, game-like elements, and interactive content to engage learners gainfully in the learning process. This involves learners reviewing instructional

materials at home, typically through videos or online resources, and then utilizing classroom time for collaborative activities, discussions, and problem-solving. In support, Yu et al. (2023) confirm that this innovative educational strategy integrates flipped classrooms with gamification to enhance learners' engagement, critical thinking, problem-solving, and motivation, thereby fostering better learning outcomes. This strategy encourages learners to become more interactive, enjoy mathematics, and develop a practical mindset by incorporating gaming elements into educational experiences through a learner-centered approach. While various studies have investigated the impact of this strategy, little to no research has investigated the effect of GFCIS on lower primary mathematics achievement in Nigeria.

Research Hypothesis

1. The Gamified Flipped Classroom Instructional Strategy has no significant main effect on learners' mathematics achievement.
2. There is no significant interaction effect between gamified flipped classroom instruction and gender.

II. Research Method

Research Design

The study employed a quasi-experimental design (Creswell & Creswell, 2018) with non-randomly selected groups and pre- and posttests. Creswell and Creswell (2018) assert that pretest measures are administered before treatment, whereas posttest measures are administered after treatment. In this case, the pretest helped confirm whether the treatment made a difference, since only the experimental group received it. Since this quasi-experimental study aimed to investigate the effect of the gamified flipped classroom strategy on Ilorin West Primary 3 Mathematics achievement by engaging a total of 74 learners as participants, it was deemed credible for trustworthiness. Of the 74 selected participants, 44 were placed in the experimental group (gamified flipped classroom) and 30 in the control group (taught the duplicate content using conventional teaching strategies). During the investigation, before conducting face-to-face classroom activities, learners in the experimental group had access to various gamified materials and other materials sent via WhatsApp (mainly video clips, PDF files, and group discussions). During classroom time, the learners engaged in these activities. Table 1 below provides the information regarding the number of learners and the number per gender.

Table 1. Research population

School	Total Number of Learners Per School	Gender	
		M	F
School A	44	19	25
School B	30	14	16

Research Procedure

The research employed a pretest-posttest control-group quasi-experimental design, focusing on three (3) learners in the lower primary school in the Ilorin West Local Government Area of Kwara State as the target population. A simple random sampling technique was applied to select two (2) privately owned primary schools. A random sampling technique was used to identify 3 schools as the experimental group for implementing the gamified flipped classroom instructional strategy, while the other served as the control group using the conventional teaching method. This study, which included three primary learners from each of the selected schools, comprised a total sample of 72 participants. In quasi-experimental designs, researchers allocate participants to groups with varying conditions without complete randomization - a method chosen when strict randomization is impractical or ethically challenging. This approach allowed for assessing the impact of an intervention or treatment in a real-world setting (Sulaimon & Manditereza, 2024).

Additionally, the study employed three research instruments: the Mathematics Achievement Test (MAT), the Guide for Gamified Flipped Classroom Instructional Strategy (GGFCIS), and the Guide for Control Group (GCG). The MAT's question items were

derived from the three primary mathematics schemes of work, comprising twenty (20) multiple-choice questions such as "What is the value of 48 divided by 6, what is the place value of 6 in 462, which of the following is an even number, which fraction shows half…". To validate these instruments, drafts of the MAT, GGFCIS, and GCG were submitted to three peer lecturers in the Faculty of Education at the University of Ilorin, Nigeria. These experts evaluated these instruments for their content relevance, clarity, alignment with curriculum goals, suitability of item difficulty levels, and suitability for lower-basic learners. Their remarks and suggestions were used to clarify unclear items, modify instructional processes, and align the instruments with the desired learning outcomes, thereby improving the overall content and face validity of the instruments.

The reliability of the mathematics achievement test was evaluated using the alternative and parallel methods. This assessment was conducted at a two-week interval and included 30 lower primary 3 learners who were not involved in the preliminary study. Data from the two administrations were analyzed using the Pearson Product-Moment Correlation (PPMC), which yielded a reliability coefficient of 0.74. The study spanned six weeks, and the results were analyzed and scrutinized using Analysis of Covariance (ANCOVA) at a significance level of 0.05.

Procedure for the Study Using Gamified Flipped Classroom Strategy

This study adhered to the following procedures at the stages of the Gamified Flipped Classroom Strategy, and the utilization of social networks such as Facebook Messenger and WhatsApp.

Stage 1: Obtain approval and consent: The researcher obtained approval from the school authorities, consent/assent from learners and parents, and then administered pretests.

Stage 2: Create WhatsApp and Facebook Messenger groups: The researcher created WhatsApp groups for the experimental group learners by using parents' contact details.

Stage 3: Record video teaching sessions: The researcher recorded video teaching sessions.

Step 4: Share instructional videos: The recorded videos were shared on the parents' WhatsApp and Facebook Messenger platforms, thus allowing learners access to lesson content before the initial classroom interaction. These videos were shared during the weekend.

Stage 5: Integrate game materials exposure: Learners were exposed to game materials related to each lesson for a week. Descriptions of the games were provided to parents alongside instructional content via WhatsApp and Facebook Messenger. The game materials were designed to complement the lesson content to enhance understanding through interactive gameplay.

Stage 6: Initial classroom interaction: The class teacher, who acted as the research assistant (trained by the researcher), facilitated collaborative discussions during the initial 4-week instruction period. Questions were presented to explore learners' understanding of the video content and the game materials.

Stage 7: Administer posttest: Following the completion of the instructional period, a posttest was administered to assess the impact of the Gamified Flipped Classroom approach on learners' learning outcomes.

III. Results and Discussion

Research Hypothesis One: *Gamified Flipped Classroom Instructional Strategy has no significant main effect on learners' mathematics achievement.*

Table 2. Summary of ANCOVA showing the main effect of gamified flipped classroom instructional strategy on learners' mathematics achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9510.097[a]	2	4755.048	13.809	.000
Intercept	7602.066	1	7602.066	22.077	.000
Pretest	409.013	1	409.013	1.188	.279
Treatment	9340.281	1	9340.281	27.125	.000
Error	24447.863	71	344.336		

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Total	307485.000	74			
Corrected Total	33957.959	73			

Table 2 above illustrates the effect of the Gamified Flipped Classroom Instructional Strategy on learners' mathematics achievement in Ilorin West Local Government Area of Kwara State. The results demonstrated a significant impact of treatment on learners' mathematics achievement ($p = .000$, $p < 0.05$), thereby rejecting the initial hypothesis. In essence, this signifies that the treatment substantially impacts learners' academic achievement in mathematics.

Table 3. Summary of Bonferroni's post hoc pairwise comparison of the scores between the gamified flipped classroom group and control group

Treatment	Mean Score	Experimental 1	Control Group
Gamified Flipped classroom strategy	76.95	*	
Conventional Method	47.37		*

Table 3 above revealed that the substantial main effect highlighted in Table 1 was attributed to notable differences between the Gamified Flipped Classroom Strategy group and the control group. Learners exposed to the Gamified Flipped Classroom Instructional Strategy exhibited a mean score of 76.95, whereas learners in the control group recorded a mean score of 47.37.

Research Hypothesis Two: There is no significant interaction effect of Gamified Flipped Classroom Instructional Strategy and gender on learners' mathematics achievement.

Table 4. Summary of ANCOVA showing the significant interaction effect of gamified flipped classroom and gender on learners' mathematics achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9510.097[a]	2	4755.048	13.809	.000
Intercept	7602.066	1	7602.066	22.077	.000
Pretest	409.013	1	409.013	1.188	.279
Treatment	9340.281	1	9340.281	27.125	.000
Treatment * Gender	312.168	1	312.168	.894	.348
Error	24447.863	71	344.336		
Total	307485.000	74			
Corrected Total	33957.959	73			

Table 4 above presents the ANCOVA summary, indicating a significant interaction effect between the Gamified Flipped Classroom and gender on learners' mathematics achievement. However, the observed p-value is higher than 0.05 ($p = .348 > 0.05$). Therefore, the previously posited hypothesis suggesting no significant interaction effect between the Gamified Flipped Classroom and gender on learners' mathematics achievement is upheld.

Discussion and implications of the study

The study's main objective is to investigate the impact of implementing a Gamified Flipped Classroom Instructional Strategy on enhancing mathematics achievement among lower primary learners and to determine the interaction effect between gender and Gamified Flipped Classroom on learners' mathematics achievement. This study revealed a significant positive effect of a gamified flipped classroom instructional strategy on learners' mathematics achievement. As described earlier, the Active Learning Theory supports this result, stating that learners gain more knowledge when they are actively involved in solving problems, reflecting, and engaging in collaborative activities. The GFCIS system provided learners with opportunities to engage with mathematical concepts individually and in groups, thereby facilitating cognitive processing and enhancing retention. The availability of gamification elements, including autonomy, challenge, and immediate feedback, aligns with Intrinsic Motivation Theory (Deci & Ryan, 1985), which explains why learners show increased effort and persistence during learning activities.

This study's results were in line with the findings of Sulaimon, Salaudeen & Awoyemi (2024), who explored the effect of creative materials on Pupils' Understanding of Mensuration Concept in Mathematics; the

findings also corroborate those of Sulaimon and Mandidereza (2024), who observed a significant positive effect of the traditional flipped classroom strategy in Teaching Primary 3 Class Mathematics. Russo, Bragg & Russo (2021) also affirmed that gamification positively affects learning when used as an add-on to flip classroom pedagogy. Sen (2022) further explains that when learners are entrusted with learning outside the classroom, they may be motivated to leverage technology, which aligns with the gamified flipped learning model and provides a comprehensive conceptual teaching framework. Nevertheless, these findings conflict with Alanazi (2020), who claims that recreational math games cause math anxiety.

The current study's results indicate that integrating gamification with a flipped classroom approach can enhance students' performance in mathematics, particularly in lower grades. These finding addresses students' need for additional time for in-class activities as a gamified flipped classroom instructional strategy that enables the acquisition of out-of-class knowledge (Sailer & Sailer, 2021). This holds significant importance for various stakeholders in education. Teachers should consider integrating gamified elements and a flipped classroom approach into their instructional strategies to improve students' mathematics achievement. On the other hand, school management should support and encourage teachers to explore innovative teaching methods, such as gamification and flipped learning, that enable targeted use of digital technologies. This can lead to more efficient and effective primary education. Policymakers should consider these study findings when designing education policies and curriculum frameworks, as this helps to facilitate the adoption of effective teaching strategies.

Unlike Dowker, Cheriton, Horton & Mark (2019) and other earlier studies (Markovits & Forgasz, 2017; Ganley & Lubienski, 2016) that claim that boys have superior abilities and are more confident in mathematics than girls, this study revealed no significant interaction effect of Gamified Flipped Classroom and gender on learners' mathematics achievement. This study's findings concur with those of Ikwuka and Okoye (2022), who assert that gender is not a significant factor in students' achievement in gamified flipped classrooms. These findings show that gamified flipped classrooms are gender friendly, implying that primary school students' mathematics academic performance is independent of their gender. In support of the study findings, Husain, Al-Shayeb & Khazalah (2023) posit that female and male primary school students' motivation to complete in gamified activities is equal. For students, this finding implies that a gamified flipped classroom as a teaching method promotes equal learning opportunities. As a result, it does not have a differential impact based on gender. These findings can help teachers and school management develop inclusive teaching strategies that do not rely on gender-based assumptions. Similarly, policymakers should consider the study findings when shaping educational policies that ensure equity in learning environments.

IV. Conclusion

The methodology for teaching and learning is a constant subject of reflection and debate in academia, particularly regarding the use of digital technologies, which continually advance in effectiveness, resources, features and functionalities. While conventional teaching techniques in the traditional classroom have been used for centuries, the study advocates the use of gamified flipped classroom techniques to help students learn in an engaging manner. The overall study findings show that a gamified flipped classroom substantially impacts learners' academic achievement in mathematics, whilst gender is not a significant factor in female and male students' achievement in using a flipped classroom. The study has valuable implications for students, teachers, school management, policymakers, and society. It extends the ongoing debates and knowledge on gamified flipped classrooms, which is valuable for education practitioners and researchers. Considering the study findings, incorporating gamified flipped classrooms on a broader societal level results in more engaged and successful students in mathematics, resulting in better-equipped

students for mathematics-oriented academic and professional pursuits, benefiting society.

Furthermore, the strategy encourages parental involvement. This could reduce disparities in educational outcomes. In addition, the study findings align with efforts to create fair and unbiased educational systems.

Nevertheless, the study primarily focused on mathematics learners. Hence, future studies can expand to include other subjects, grades, geographical contexts, and a larger scale. This current study's limitations provide opportunities for future studies to be groundbreaking. Recommendations are made to include the effects of other demographic variables (such as age), motivational factors and academic competency.

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