USING FLIPPED LEARNING TO REDUCE MATHEMATICS ANXIETY OF PRIMARY SCHOOL STUDENTS

Yusuf KARAKOC
ORCID:0009-0009-1937-1585
Faculty of Education
Yozgat Bozok University
Yozgat, TURKIYE

Dr. Kevser HAVA
ORCID: 0000-0003-3822-6796
Faculty of Education
Yozgat Bozok University
Yozgat, TURKIYE

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ABSTRACT

This study aimed to investigate the effects of flipped learning on mathematics anxiety among primary school students. An embedded mixed-methods design was employed for this study. The participants in the 8-week intervention were 3rd-grade primary school students attending a public school in Turkiye. Data for the study was collected through the use of the mathematics anxiety scale, interview form, student diaries, and observation instrument. The collected data was analysed utilizing the Wilcoxon Signed Rank Test for quantitative analysis and inductive content analysis methods for qualitative analysis. The quantitative analysis indicated that the flipped learning significantly reduced mathematics anxiety among primary school students and enhanced student participation. The qualitative analysis produced four main themes: in-class learning activities, student participation, technology and internet usage, and learning resources. The findings revealed that the incorporation of in-class learning activities in the flipped learning facilitated a better comprehension of mathematical concepts among students and fostered positive attitudes toward mathematics lessons.

Keywords: Flipped learning, mathematics anxiety, student participation, primary school students, mathematics education, 3rd grade, and in-class learning activities.

INTRODUCTION

Mathematics constitutes one of the foundational disciplines within the STEM (Science, Technology, Engineering, and Mathematics) fields. Therefore, mathematics has historically been regarded as a fundamental tool for survival and social development (Segumpan & Tan, 2018). Engaging students in the study of mathematics is essential for retaining their interest in STEM fields, thereby facilitating their contributions to the sustainable development of society (Lo & Hew, 2021). However, an examination of the results from various international assessments reveals that mathematical achievement in many nations is significantly below the desired level (OECD, 2023; TIMSS, 2020).

Despite its significance in everyday life, mathematics is frequently perceived as a challenging subject by students (Yuksel-Sahin, 2008; Zhao et al., 2021). The abstract nature of mathematical concepts leads students to view this discipline as more complex and demanding compared to other disciplines (Fung, Besser, & Poon, 2021). The literature indicates that children experience mathematics anxiety from a very young age, which adversely impacts their mathematics achievement (Ersozlu, 2024; Ramirez et al. 2016). Furthermore, mathematics anxiety and mathematics achievement have been correlated with career interests and choices within STEM fields (Furner & Gonzalez-DeHass, 2011).

The objective of this study was to reduce mathematics anxiety among primary school students and to enhance their participation in mathematics classes through the implementation of the flipped learning. The study aims to contribute to the limited literature on the enactment of the flipped learning in primary school mathematics contexts and offers potential implications for practice by exploring practices and factors that may influence students' motivation to engage in mathematics classes. The insights derived from this study can assist educators in making informed instructional decisions related to student engagement in the context of flipped learning. Moreover, if students recognize a pedagogical advantage in utilizing flipped lessons, this perception may influence the future adoption of flipped learning in primary education.

Math Anxiety

Mathematics anxiety is characterized by feelings of apprehension and heightened physiological arousal associated with mathematical tasks, including engaging with numerical concepts, solving mathematical problems, or participating in mathematics-related assessment scenarios (Luttenberger, Wimmer, & Paechter, 2018). This construct is multifaceted, encompassing various dimensions such as personality traits, self-concept, self-esteem, avoidance of mathematics, as well as emotional and cognitive factors (Hadfield & McNcil, 1994). Students exhibiting mathematics anxiety frequently demonstrate a tendency to avoid mathematics courses (Hembree, 1990; Cevikbas & Kaiser, 2022). For these individuals, mathematics not only elicits feelings of aversion or anxiety but also influences physiological responses, including heart rate, neural activation, and cortisol levels (Faust, 1992 cited in Ramirez et al. 2018). Consequently, individuals with mathematics anxiety report heightened anxiety in contexts related to mathematics, and this anxiety can have an immediate impact on performance in mathematics-related scenarios, such as examinations and classroom settings (Ersozlu, 2024; Furner & Gonzalez-DeHass, 2011).

Antecedents of mathematics anxiety can be categorized into personal and environmental characteristics. Personal antecedents pertain to individual factors, such as prior knowledge, trait anxiety, and gender, whereas environmental antecedents encompass elements including educational experiences, cultural values, and the influence of significant others in one's life (Luttenberger, Wimmer, & Paechter, 2018). According to Segumpan and Tan (2018), mathematics anxiety primarily originates from detrimental experiences encountered in mathematics classrooms. In a systematic review conducted by Ersozlu (2024), it was demonstrated that active and supportive involvement of parents in the educational process significantly enhanced primary students' motivation for mathematics, as well as their levels of participation and academic success. Furthermore, the emotional enrichment of learning environments and the implementation of engaging teaching methods facilitated the development of positive attitudes toward mathematics among students by mitigating mathematics anxiety.

Math Education

In the field of mathematics education, there exist well-defined hierarchical relationships among mathematical concepts and principles, necessitating adherence to a specific sequential order for effective learning (Yang, Lin, & Hwang, 2021). This phenomenon can be attributed to the cumulative nature of mathematics learning; specifically, students who struggle to comprehend fundamental concepts often encounter challenges when attempting to master more advanced concepts that rely on these foundational principles (Gunderson et al., 2018). Integrating student-centred, inquiry-based learning processes into mathematics instruction presents a significant challenge (Dove & Dove, 2017; Zhao et al., 2021).

Since mathematics frequently explores concepts in an abstract manner, diverse methods and techniques are required for effectively teaching these concepts (Fung, Besser, & Poon, 2021; Hwang, & Lai, 2017; Zhao et al., 2021). Currently, educators are urged to adopt flipped learning as a strategy to alleviate student anxiety in mathematics classes (Cevikbas & Kaiser, 2020; Dove & Dove, 2017; Guler et al., 2023; Kaya, 2018; Niyaie et al., 2021; Segumpan & Tan, 2018; Toh et al., 2017). When examining the relevant meta-analytical studies within the existing literature, it becomes evident that flipped learning demonstrates greater efficacy than traditional pedagogical approaches in enhancing mathematics achievement (Yakar, 2021). Flipped learning has the potential to serve as a crucial instrument in transforming students' attitudes towards mathematics,

fostering a more positive disposition towards the subject, promoting increased engagement in the learning process, and simultaneously elevating their levels of self-efficacy (Cevikbas & Kaiser, 2020; Kaya, 2018).

Flipped Learning

Flipped learning is a pedagogical approach that involves the use of videos and various materials to support learning at home. Its foundation lies in the belief that if students come to school having necessary pre-learning of a subject at home, then there will be less anxiety, more active participation, and better learning in classroom (Mok, 2014). In essence, it entails a reversal of the traditional education system. The term "flipped learning" was first coined by J. Wesley Baker in his work entitled *"The Classroom Flip: Becoming the Guide by the Side"* in 2000. The first implementation of this approach took place in a high school in the United States, where two chemistry teachers prepared videos on course content for students to watch at their own convenience. Subsequently, the teachers encouraged students to watch the videos outside of class and engage in classroom activities during class time.

Flipped learning represents a student-centric approach to instruction, which falls under the umbrella of blended learning models (Hwang et al., 2015). In this model, students arrive at class already equipped with educational videos that have been provided in advance. By assimilating the information outside of the classroom, students are able to enhance their understanding of the subject matter through supplementary studies and activities during school hours (Cevikbas & Kaiser, 2020; Zhao et al., 2021). However, in traditional learning environments, students often lack adequate preparation prior to the lesson (Segumpan & Tan, 2018). Unlike traditional learning environments, flipped learning presents a pedagogical framework that facilitates the incorporation of various activities aimed at equipping students with advanced skills, including reasoning and problem-solving capabilities (Lopes & Soares, 2018; Yakar, 2021). Flipped learning accommodates the evolving learning preferences of students who have been raised in an environment characterized by technological innovations, including computers, smartphones, and social networks (Mosher, 2016).

Although flipped learning presents numerous educational advantages, it is not without its limitations. One notable limitation is the necessity for students to possess adequate information technology skills to effectively engage with content delivered by instructors on various devices, including tablets, smartphones, and computers (Jenkins, 2012). Furthermore, the creation of video content for flipped learning demands a considerable investment of time from educators (Muir & Geiger, 2016). Additionally, there exists the possibility that students may arrive in class without having viewed the assigned videos (Cevikbas & Kaiser, 2020; Lai & Hwang, 2016). Another drawback is that the videos utilized in flipped learning are typically non-interactive, thereby restricting students' opportunities to pose questions regarding concepts they find challenging to comprehend (Talbert, 2012).

Flipped Learning in Mathematics Education

Various studies in the literature demonstrate the positive effects of flipped learning on student achievement and motivation within the context of mathematics education. However, the majority of these studies have been conducted at the high school (Bhagat et al., 2016; Casem, 2016; Deliktas & Stojkovska, 2019; Durong et al., 2018; Esperanza et al., 2016; Graziano & Hall, 2017; Lo & Hew, 2017; Muir, 2021; Muir & Geiger, 2016; Toh et al., 2017; Vang, 2017; Zeineddine, 2018) or undergraduate (Zengin, 2017; Dove & Dove, 2017; Lopes & Soares, 2018; Yorganci, 2020) levels of education, with a limited number of investigations focusing specifically on the secondary school level (Clark, 2015; Egara & Mosimege, 2024; Kaya, 2018; Montgomery, 2015; Segumpan & Tan, 2018; Wei et al., 2020). In this regard, Kaya's (2018) study is particularly valuable as it illustrates that flipped learning significantly enhances student participation in secondary school mathematics courses. The findings reveal that flipped learning not only positively influences students' attitudes toward the course but also promotes their engagement in active learning processes. Similarly, the research conducted by Segumpan and Tan (2018) examined the impact of flipped learning on secondary school students' achievement in mathematics and their levels of mathematics anxiety. The results indicated that students engaged in flipped learning exhibited greater success in recalling academic

concepts, accompanied by a reduction in their mathematics anxiety. Moreover, Clark (2015) observed an increase in the active participation of secondary school students during mathematics lessons conducted in a flipped learning environment. This study further indicated that secondary school students demonstrated a higher level of interest in flipped learning compared to traditional learning methods. Additionally, D'addato and Miller (2016) explored the application of flipped learning in fourth grade mathematics education at the primary school level. Their findings suggested that flipped learning fostered self-confidence and intrinsic motivation in students, who actively participated in the learning process and assumed responsibility for their own educational journeys. In the study conducted by Mosher (2016), it was determined that primary school students expressed satisfaction with the increased personal learning time spent with the teacher and the enhanced involvement of their parents during homework sessions, attributable to the implementation of flipped learning in mathematics classes. Furthermore, Jackson (2019) investigated the effects of flipped learning on mathematics achievement. The findings substantiate the claim that flipped learning instruction can improve student learning outcomes for elementary students. Similarly, a study conducted by Niyaie et al. (2021) examined the impact of flipped learning on the mathematics anxiety and performance of fifth-grade primary school students. The findings indicated that flipped learning was significantly more effective in alleviating students' mathematics anxiety and enhancing their performance in mathematics compared to traditional instructional methods. Another study demonstrated that gamified flipped learning is effective in enhancing the motivation and belief levels in mathematics among third-grade primary school students (Genc & Aydin, 2023).

The Significance of The Study

Mathematics is a fundamental discipline that should be introduced at an early age due to its numerous applications in everyday life (Hastuti, 2020). Childhood represents a critical period in human development, during which appropriate pedagogical approaches can substantially influence students' academic performance and creativity within both their personal and social contexts (Moghadam & Razavi, 2022). Mathematics anxiety among students typically manifests during the early years of their educational experience (Yuksel-Sahin, 2008).

In traditional mathematics education, educators typically engage in extensive explanations of the subject matter during instructional periods, allocate time to solve a limited number of sample problems, and assign homework to reinforce understanding of the content (Kavaz & Kocak, 2024). Traditional learning methods restrict student interaction, primarily promote student-teacher engagement, and pose challenges to learners' comprehension of content (Deliktas & Stojkovska, 2019). Consequently, there is an imperative to adopt innovative pedagogical approaches within mathematics instruction. Nevertheless, research on the implementation of flipped learning as a strategy to mitigate mathematics anxiety among primary school students remains limited. The characteristics of primary school students diverge significantly from those of higher education students, not only in terms of age but also concerning their capacities for self-directed learning and collaborative teamwork (Yakar, 2021). Therefore, it is crucial to explore the effectiveness of flipped learning in primary mathematics education.

The research questions are given below:

- Can the mathematics anxiety of primary school students be alleviated through the implementation of flipped learning?
- To what extent do primary school students actively engage in mathematics lessons delivered through flipped learning?
- What are the perceptions of primary school students regarding the implementation of flipped learning in mathematics lessons?

METHOD

Research Model

In this study, an embedded mixed research design was employed. This design facilitates the simultaneous or sequential collection of quantitative and qualitative data, which serve complementary functions (Morgan, 2013). This approach capitalizes on the strengths of quantitative data while also leveraging the depth of understanding afforded by qualitative data (Creswell & Plano Clark, 2018). In the quantitative component of this study, pretest and posttest assessments were utilized, while the qualitative component comprised student interviews, observation instrument, and student diaries as data collection instruments. A mixed-methods approach was adopted to gain a comprehensive understanding of the effects of flipped learning. While quantitative data measured changes in mathematics anxiety, qualitative data provided contextual insights into students' engagement and perceptions

Participants

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Yozgat Bozok University Social and Human Sciences Ethics Committee (Approval No: 04-39/20.06.2023). Before the study commenced, all participants and their parents were fully informed about the purpose, procedures, potential risks, and benefits of the research. Written informed consent was obtained from both the participants and their parents. Confidentiality of all participant data was ensured, and participants were informed of their right to withdraw from the study at any time without any negative consequences.

The implementation process of this study was conducted in a public school in Yozgat, Turkiye. The purposeful sampling method was employed in this study. It was chosen because the researcher, who was also a classroom teacher of the students in the study group, sought to address the perceived issues in the teaching process. A total of 10 third-grade primary school students, consisting of 6 males and 4 females, participated in the study. The majority of the participants' parents have a limited level of education. The school where the implementation process took place is situated in a socio-economically disadvantaged area. While all participants have access to the internet, only 3 students possess a personal computer. The implementation process of the study was conducted across the entire class.

Implementation Process

The study was conducted during the fall term of the 2023-2024 Academic Year, specifically in the 3rd grade primary school mathematics course. The implementation process spanned 8 weeks, with 2 activities taking place per week, totalling 16 hours. The course activities were scheduled for Mondays and Fridays. The lesson plans utilized in the study were carefully crafted by the researcher to align with the curriculum. These plans underwent rigorous scrutiny by an expert in the field of mathematics education, ensuring necessary corrections were implemented based on the expert's feedback.

Prior to the application process, the students were provided with information regarding the implementation of flipped learning and were advised to review educational videos prior to attending class. The selection of educational videos employed in this study was based on expert opinions and drawn from both the Education Information Network (EBA) and YouTube platforms. EBA is an educational platform developed by the Ministry of National Education (MoNE) encompasses a variety of learning activities readily accessible to students. Links to these videos were shared with the students two days in advance of their respective classes. Subsequently, the students' video consumption was assessed through the EBA platform, while parents verified whether the videos on the YouTube platform had been viewed or not.

The application process took place in a mathematics class for 3rd graders at a primary school. This lesson encompassed various topics including rounding, comparison, rhythmic counting, odd and even numbers, Roman numerals, and addition. The lesson plans included student-centred teaching activities such as peer teaching, group work, educational games, and competitions. Various activities were carried out as illustrated in Figures 1 and 2. The classroom was equipped with a smart board. For more detailed information about the implementation process, please refer to Table 1.

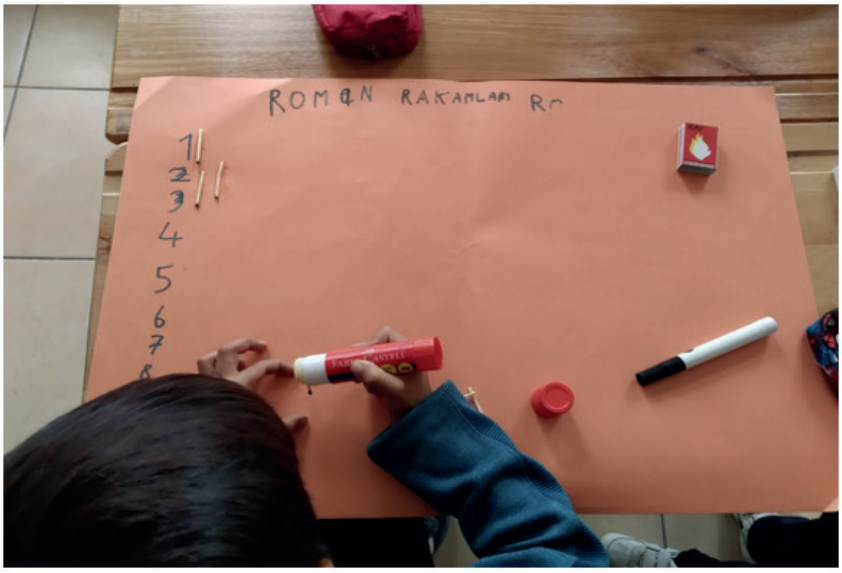

Figure 1. The activity of writing Roman numerals onto a cardboard using matchsticks

Figure 2. Playing games through the Web 2.0 tool

Table 1. The implementation process

Week	Topic	Activities
1	Rounding to tens and hundreds	• Playing basketball involves throwing the ball by rolling it • Playing the number rounding game with the Wordwall Web 2.0 tool
2	Comparing and Ordering Natural Numbers	• Playing a game in class to sort numbers. • Playing the rolling game from TEGM Material Website
3	Rhythmic Counting	• Quick tour active learning application • Engaging in rhythmic counting with the aid of a background card
4	Odd and Even Natural Numbers	• Playing the game forward if the number is odd or backward in the schoolyard • Playing games using the LearningApps tool
5	Roman Numerals	• Writing Roman Numerals on cardboard backgrounds using matchsticks • A competition on Roman numerals was conducted in the classroom
6	Addition I	• Play an in-class addition game by writing an acrostic using addition • The students performed addition by selecting their own numbers
7	Addition II	• Engaging in the utilization of Web 2.0 games through the implementation of a smart board • Peer learning activity with Yes/No Cards
8	Addition III	• Playing the game from TEGM Material website • Talking circle activity

Data Collection Tools

Math anxiety scale: In this study, the mathematics anxiety scale for primary students developed by Bindak (2005) was utilized to assess students' mathematics anxiety. The scale was administered to the study group at the beginning and end of the implementation process. The internal consistency of the scale, as measured by Cronbach's Alpha coefficient, was calculated to be 0.84. The maximum attainable anxiety score is 80, while the minimum score is 16. This scale is delineated in Appendix A.

Class participation observation instrument: The class participation observation instrument was utilized to assess the engagement levels of students within the study group during classroom activities. This form was devised by the researcher in accordance with the perspectives of an expert in the field of educational technologies. The items included in this form encompass students' punctuality, active participation through raising their hands during class, enthusiasm and interest in class, as well as their completion of tasks within activities. The scoring of the items within the form ranges from 1 to 5. Throughout the implementation phase, students were observed by a field expert who completed the lesson participation observation instruments accordingly. This instrument is delineated in Appendix B. Observation criteria were designed to assess students' in-class engagement, including:

- Punctuality in arriving to class
- Frequency of raising hands during classroom discussions
- Demonstration of willingness and interest in the lesson
- Completion of responsibilities in event management activities

Student interview form: In the conducted study, the student interview form was administered as the final step of the application process with the purpose of eliciting the participants' perspectives on flipped learning. The questions included in the student interview form were carefully constructed by the researcher in accordance with the guidance provided by an expert in the domain of Educational Technologies. The interviews were carried out individually with the students within an empty classroom setting. To ensure data preservation, the interviews were digitally recorded. The duration of each student interview ranged between 10 to 20 minutes. This form is delineated in Appendix C. Sample interview questions included:

- What are your impressions regarding the lecture videos? What activities did you engage in while viewing the course videos outside of the classroom? Did you encounter any challenges?
- What is your opinion on the practice of watching course videos outside of the classroom and focusing solely on in-class activities?

Student diaries: Throughout the implementation process, students were requested to maintain diaries subsequent to each lesson to gather their perspectives on the activities.

Data Analysis

The quantitative data obtained from the research were analysed using the SPSS 27 program. The anxiety scale was administered as both a pretest and a posttest. Descriptive statistics (mean, standard deviation, minimum, and maximum) were used to determine the levels of mathematics anxiety among students. The Kolmogorov-Smirnov Test was employed to assess whether the data followed a normal distribution. A significance level of 0.01 was utilized for the quantitative analysis. Since the quantitative data did not meet the assumption of normality, the Wilcoxon Signed Rank Test was employed for analysis.

Inductive content analysis was employed to examine the responses to the open-ended questions. This method involves the generation of categories derived from the data and consists of three stages: open coding, category creation, and abstraction (Elo & Kyngas, 2008). To ensure reliability in qualitative analysis, two researchers independently coded the data, and inter-coder agreement was calculated using Cohen's Kappa ($\kappa = 0.82$), indicating substantial agreement. The findings were presented with direct quotations to enhance the validity of the data.

FINDINGS

Can the Mathematics Anxiety of Primary School Students be Alleviated through the Implementation of Flipped Learning?

In the present study, the findings of the descriptive analysis concerning the pretest and posttest scores are displayed in Table 2. As depicted in Table 2, the average pretest score for the students is 2.37, whereas the average posttest score is 1.38. It is evident that the students' posttest scores are lower in comparison to their pretest scores.

Table 2. Descriptive analysis results regarding pretest and posttest scores

	N	Min	Mak	Mean	SS
Pretest	10	1.5	3.00	2.37	.59
Posttest	10	1,10	2.00	1.38	.31

The Wilcoxon Signed Rank Test was utilized to determine the significance of the difference between the pretest and posttest scores. The analysis results are presented in Table 3. Upon examination of Table 3, it becomes evident that the difference between the pretest and posttest scores of the students in the study group is statistically significant ($z=-2.805$; $p<0.05$). Regarding the average and total of the difference scores, this difference favored negative ranks, i.e., the pretest score. Consequently, the effect size was determined to be high. The Eta squared value was found to be $\eta^2 = 2.10$. Based on these findings, it can be concluded that flipped learning is effective in reducing mathematics anxiety among primary school students.

Table 3. Results of the Wilcoxon Signed-Rank Test

		N	Rank average	Rank total	z	p
Pretest - Posttest	Negative rank	10[a]	5.50	55.00	-2.805	0.005
	Positive rank	0[b]	0.00	.00		
	Equal	0[c]				

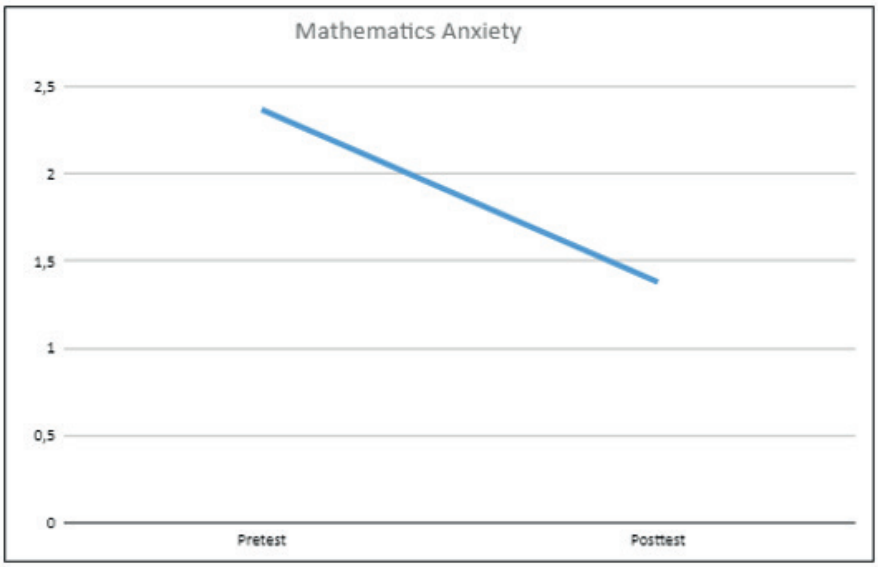

Figure 3. Difference between posttest and pretest scores

What is the Extent of Primary School Students' Participation in the Mathematics Course Implemented Using Flipped Learning?

During the implementation process, a class participation observation instrument was used to determine the level of student engagement in classroom learning activities in flipped learning. The findings obtained from the observation instrument are presented in Figure 4.

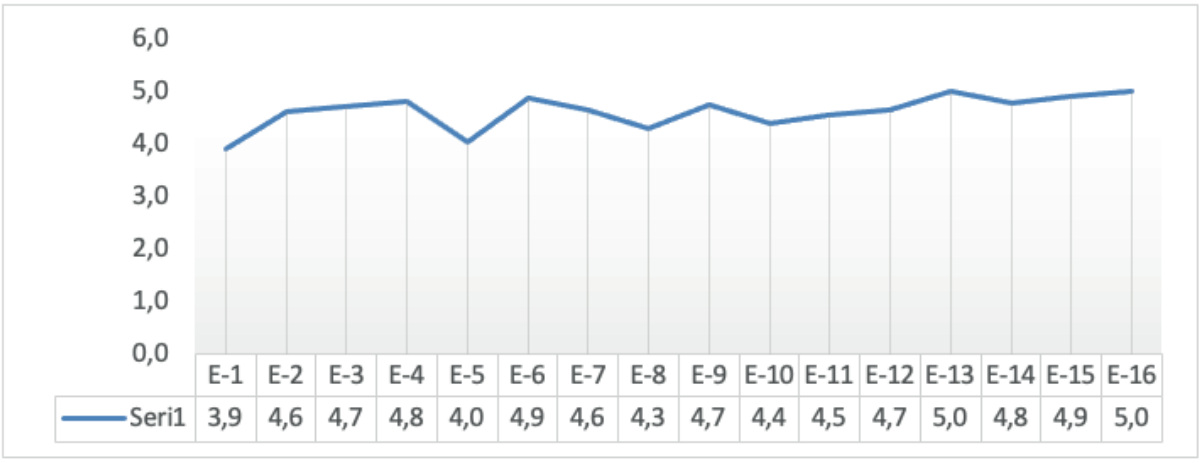

Figure 4. Findings obtained from the class participation observation instrument (E: Activity)

When Figure 4 is examined, it can be observed that class participation increased in the first four activities, but decreased in activity 5. Subsequent activities displayed varying levels of class participation, with the highest levels observed in activity 13 and activity 16. Conversely, activity 1 and activity 5 had the lowest levels of participation.

Activity 5, which had the lowest participation, involved a "quick tour" activity related to the achievement of *"Rhythmic Counting Forward by Six, Seven, Eight, and Nine Up to 100". The opinions of students regarding these activities are presented below:*

> *"We played a rhythmic counting game, and the game was very good, but I couldn't win the game." (S1)*
>
> *"Rhythmic counting by sixes was very complicated. (S5)*
>
> *"The topic was rhythmic counting, it was nice. The game was good, but I made a mistake. The name of the game is quick tour. It was fun, we didn't play from the smart board this time." (S9)*

Upon examining student opinions, it becomes apparent that the competitive nature of the quick tour activity had a negative impact on certain students and caused confusion among others.

What are the Perceptions of Primary School Students regarding the Implementation of Flipped Learning in Mathematics Lessons?

As a consequence of conducting an analysis of the qualitative data collected, four themes were identified: in-class learning activities, student participation, technology and internet use, and learning resources. These emerging themes and their respective categories are presented in Figure 5.

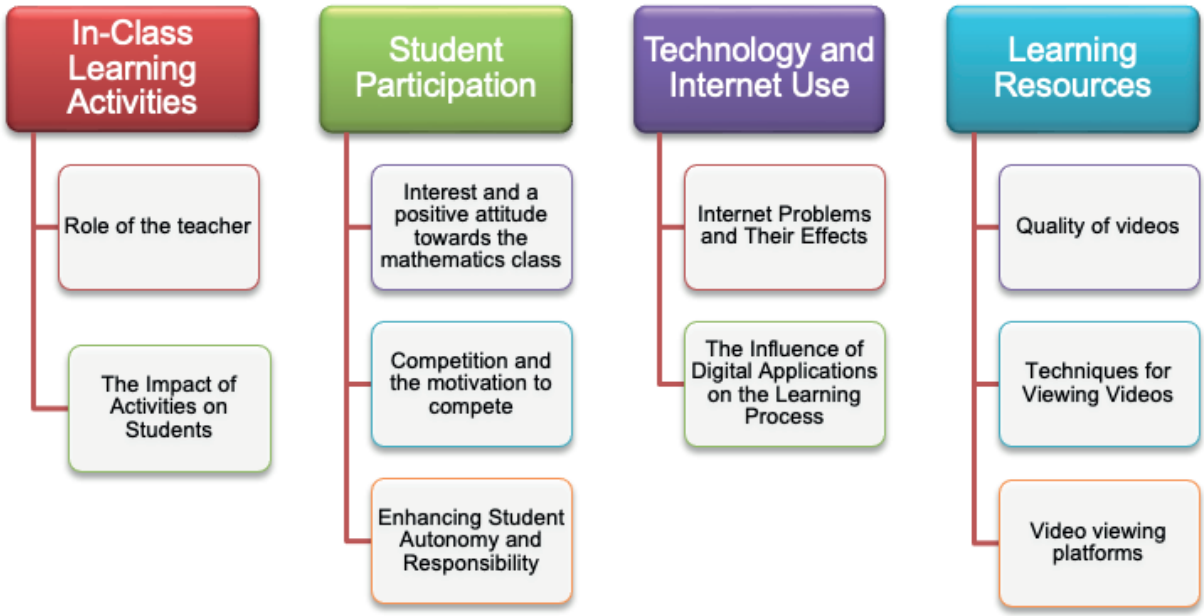

Figure 5. Themes and categories that have emerged as a result of the analysis of qualitative data

In-Class Learning Activities

Within the context of in-classroom learning activities, two distinct categories can be identified: the teacher's role and the impact of these activities on students. The results of the study indicate that in flipped learning, the teacher assumes a more guiding role rather than simply imparting knowledge to the students. In relation to this, one student (S1) stated, *"Some students struggled with the activities, but my teacher provided assistance."* Another student (S3) expressed, *"We listen and learn at home, and then engage in collaborative activities at school. Our teacher is also there to support us."* The opinions of other students are presented below:

"I inadvertently neglected to view certain videos, but upon your reminder, I also proceeded to watch them." (S8)

"Our instructor rectifies errors made by individuals." (S9)

Conversely, the students expressed that the teacher failed to provide an explanation of the topic during the lesson as a result of flipped learning; they claimed that this approach required less exertion on their part. Regarding this, S2 stated, *"You do not experience fatigue during the activities"* while S5 remarked, *"We simultaneously acquire knowledge and derive pleasure from viewing instructional videos outside the classroom and engaging in activities within it. We also experience a sense of rejuvenation,"* they added.

The findings of the study indicated that the learning activities implemented during the course yielded positive outcomes for the students. The students expressed their enjoyment and increased satisfaction with their mathematics lessons as a result of these activities. For instance, S1 remarked, *"It was a pleasant experience. The educational videos we watched at home were also engaging, and the hands-on activities we participated in during class were enjoyable and stimulating."* Similarly, S2 shared, *"I found the activities we conducted in class to be captivating. The combination of the instructional videos and the practical tasks proved to be beneficial for the students."* S7 concurred, stating, *"The learning activities were highly enjoyable and entertaining. I personally found them to be quite engaging."* Likewise, S8 expressed, *"All of the activities were excellent, surpassing the quality of mathematics lessons taught in the previous year."* S9 enthusiastically endorsed the approach, exclaiming, *"It was exceptionally good, and I genuinely loved it. I wish all classes could be as engaging as this one."* S10 added, *"The activities were not only educational but also fun. We certainly did not experience this level of enjoyment in our regular classes."*

Student Participation

The findings of the study indicate that the implementation of flipped learning resulted in a notable increase in students' interest and positive attitudes toward mathematics lessons. Additionally, it was observed that students experienced a reduction in mathematical anxiety throughout the flipped learning process. For instance, one student (S1) expressed a newfound appreciation for mathematics, while another student (S2) mentioned that mathematics has become their favourite subject, surpassing their previous preference for Life Sciences. Similarly, several other students (S3, S7, S8, and S10) reported an increased affinity for mathematics, emphasizing the positive impact of the activities conducted as part of flipped learning. Moreover, a significant improvement in confidence was observed in one student (S9) who previously harboured a fear of making mistakes in mathematics but now feels completely at ease with the subject.

Students demonstrated a high level of engagement in the in-class learning activities conducted during the flipped learning process. Specifically, competitive activities stimulated a sense of competition among students, resulting in increased participation in the learning process. For instance, S1 expressed satisfaction with their group's performance in a rhythmic counting caterpillar activity, stating, *"We executed it excellently, and both my teacher and I were pleased. Our group achieved first place, which made me very happy, and my group members were also delighted*." Similarly, S4 described the excitement felt by their classmate who emerged as the winner of a game, noting, *"Our friend was ecstatic, and naturally, we were also filled with joy."* S6 reflected on the captivating nature of the smart board game, exclaiming, *"The game on the smart board was thoroughly enjoyable, and I am proud of myself."* Furthermore, S7 shared their experience of playing a board game with friends, emphasizing the beauty of the scoring system. S8 appreciated the aesthetic appeal of the caterpillars they created and acknowledged the skill of the opposing team. These expressions highlight the students' enthusiasm for the competitive aspect of the learning process. In addition, S3 remarked, *"It was evident that the videos were highly beneficial to my friend. Although they were slightly helpful to me as well, since I reached the finals, I didn't win. Nonetheless, it was a fantastic experience,*" emphasizing that the videos played a crucial role in their friend's first-place achievement.

In the analysis, it was concluded that students were accountable for reviewing educational videos prior to attending class. Consequently, students have become cognizant of the necessity to diligently watch even the videos they may not find appealing. This circumstance has contributed to the cultivation of students' sense of responsibility. In relation to this matter, S2 demonstrated responsibility by stating, *"I may not enjoy watching the blackboard, but it is imperative for me to do so in order to acquire knowledge."* S3 mentioned, *"Although I*

emerged victorious in the odd-even game, it is evident that others had watched the video at least once. I cannot recall whether I watched it three or five times." S7 shared, *"There was a video about even and odd numbers. They emphasized the importance of watching the videos attentively*, stating, *'Some individuals did not watch diligently, but I personally paid close attention to it*.'" Conversely, S8 remarked, *"The more one watches the videos, the more beneficial they become. I found the videos quite engaging, and I believe they were well-received by everyone."* S10 expressed that they repeatedly viewed the videos until they comprehended the subject matter fully, stating, *"I watched the videos until I obtained a thorough understanding of the material."*

Technology and Internet Use

The analyses indicated that students encountered difficulties when attempting to watch educational videos prior to class. Specifically, some students reported being unable to access the videos due to the exhaustion of their parents' mobile internet quotas. Consequently, students who were unable to view the videos at home were given the opportunity to do so within the school environment. One student, S4, explained, *"I was unable to watch the video at home as my mother had used up her internet data, and my father did not purchase additional internet for her."* Another student, S8, shared:

> *"I wanted to watch the video, but my mother informed me that there was still time and that I could watch it later. However, my brother had already exceeded his internet data limit. As a result, our teacher instructed me to watch the videos at school."*

In the study, it was established that the students found the digital applications utilized in the flipped learning process to be highly engaging and appealing. Regarding this matter, S2 stated, *"I thoroughly enjoyed the games on the smart board."* S3 mentioned, *"The activities are quite enjoyable, although it would be even better if there were computer games."* S4 expressed, *"I absolutely loved the airplane game, adored the mole game, enjoyed the number game, and was fond of the train game."* S7 commented, *"The activities we conducted on the interactive whiteboard were superior."* S8 conveyed, *"The airplane game was delightful and I found it particularly enjoyable. The mole game was delightful and I loved it. I greatly enjoyed the math activity. I particularly enjoyed the rocket game."* On the other hand, some students were more content with activities that involved group work or physical materials. In relation to this topic, S1 remarked, *"The work we did with cardboard was pleasant and enjoyable."* S5 mentioned, *"The activity we engaged in with matches on a background card involving Roman numerals."* S6 stated, *"We constructed Roman numerals using matches, and that was pleasant." We also had a number affixed to us, which was also enjoyable. We also participated in a game of yes or no, a talking circle and that was highly enjoyable as well."* S9 expressed, *"We made mistakes with the Roman numerals and matches, but I still found it enjoyable."* S10 recalled, *"Do you remember the initial game we played, where we wrote numbers, sorted them from large to small and constructed them using cardboard? The work was commendable."* They shared their perspectives in the following manner.

Learning Resources

The findings indicate that the students had a positive perception of the videos used in the flipped learning process. S1 expressed, *"The videos were enjoyable and engaging. It would have been better if they had never ended."* S4 stated, *"I really liked the videos; the content was of high quality."* S5 commented, *"I enjoyed all the videos. They were informative and easy to understand."* S6 emphasized, *"The lesson videos were excellent. They allowed us to have fun while learning. The key is to learn while enjoying the process."* S8 added, *"I liked the videos a lot, and I believe my friends did too. They were both entertaining and educational."*

On the other hand, the study highlighted the significance of video quality. Many students paid attention to factors such as sound quality, text clarity, physical appearance of the presenter, and the materials used in the videos. S2 mentioned, *"The computer used in the first video was of high quality, indicating wealth. The video was easy to follow."* S3 commented, "*The videos had a positive impact, although I got a bit distracted by the presenter's hair."* S3 also remarked, *"The videos were good, but the writing was poorly presented and difficult to read. The volume was a bit too loud."* S10 expressed, *"I really enjoyed the video, although I didn't like the presenter's voice. Both videos were well-made."* S10 further elaborated,

> *"The videos were great. One explained how to rank numbers, while the other focused on evaluation. However, I didn't like the presenter in the evaluation video, but I really enjoyed the voice of the person who explained how to sort numbers."*

These statements demonstrate that the students and teachers paid attention to various aspects of the videos, including the presenter's voice and appearance, text clarity, and overall video quality.

In the analysis, it was found that the majority of the students engaged in note-taking while watching the videos and re-watched the videos if they did not understand the content. Regarding this, S8 mentioned, *"I paid close attention and watched each video once or twice."* S10 stated, *"I consistently watched the videos in the evenings. I watched them extensively to enhance my learning."* They emphasized that they watched the videos repeatedly, without requiring any additional effort. S2 stated, *"I made sure to take notes in my notebook while watching the videos, as I feared I might forget the information. I refer back to my notes when reviewing the content."* S3 explained:

> *"I took notes in my notebook to ensure I wouldn't forget the concepts presented in the videos. For instance, when watching the video about addition, I transcribed the steps in my notebook, paused the video, and attempted to solve it independently. This method enabled me to anticipate the outcome, which was beneficial."*

S6 shared, *"I reviewed the videos by writing down key points on a separate sheet of paper and studying them. I handed the written papers to my mother, who asked me questions about the material. I answered without consulting my notes."* S9 mentioned, *"The videos included questions, so I jotted them down in my notebook and solved them. I showed my answers to my parents, who confirmed their accuracy."* They expressed that note-taking while watching the videos and receiving support from their families were crucial for their learning process. On the other hand, some students indicated that they did not take any specific actions while watching the videos. In this regard, S1 stated, "*I played the videos, and the teacher taught the lesson. So I sat on the couch and watched it." S4 explained, "Initially, I played the videos, sat back, and watched them. I did not feel the need to take notes."*

Within the scope of the study, it was discovered that the majority of the students expressed greater satisfaction and happiness with the EBA video viewing platform in comparison to YouTube. S2 expressed their preference by stating,

> *"I have never been fond of EBA, but now I don't like YouTube either. YouTube is quite boring. The videos on EBA are more informative. On YouTube, people talk incessantly. They do not write on the board, unlike the colourful and interesting content found on EBA."*

S3 shared a similar statement saying, *"I did not enjoy the videos on YouTube, but I liked the ones on EBA. Despite the absence of interactivity, the videos are still very enjoyable."* S6 enthusiastically expressed their satisfaction, stating, *"I watched a video on EBA yesterday and I absolutely loved it. It was the most beautiful video I have ever seen." S7 concurred, saying, "The video on EBA was truly enjoyable."* These are the expressions provided by the students. Only one student expressed a preference for the YouTube viewing platform. Regarding this matter, the student stated, *"We watched one video on EBA and one on YouTube. YouTube was the better option" (S9).*

DISCUSSIONS AND CONCLUSION

In this study, we aimed to reduce mathematics anxiety among primary school students and enhance their engagement in mathematics classes through the implementation of flipped learning. Data analysis indicated a statistically significant difference between the pretest and posttest mathematics anxiety scores of students who participated in flipped learning. These findings provide empirical support for the effectiveness of flipped learning in reducing mathematics anxiety among primary school students. Additionally, students engage more actively in the processes of learning and knowledge creation, as well as in the testing and evaluation of their understanding. Flipped learning facilitates students in developing a comprehensive understanding of their individual learning styles and practices. Increased student engagement through active learning opportunities fosters deeper cognitive processing, promotes higher-order thinking, and cultivates greater student confidence within flipped learning. Participants reported devoting more time to active learning experiences and collaborative activities, which enabled them to present more realistic and practical problem-

solving scenarios. This approach, in turn, resulted in enhanced student engagement and a greater sense of ownership over their learning.

A review of the literature reveals studies that corroborate the findings of this research. For example, Deliktas and Stojkovska (2019) conducted a study exploring the impact of flipped learning on mathematics achievement and anxiety. Their results demonstrated that flipped learning was more effective than traditional teaching methods in reducing mathematics anxiety. Similarly, Segumpan and Tan (2018) conducted a study that confirmed the effectiveness of flipped learning in reducing mathematics anxiety among high school students.

In this study, a range of classroom activities was implemented to integrate flipped learning into mathematics instruction. Based on the findings derived from the observation instrument, it can be generally concluded that student participation in mathematics courses utilizing flipped learning is significantly high. During the mathematics lessons structured around flipped learning, students actively participated in various active learning activities, which were conducted both individually and in groups. Observations indicated that students demonstrated a willingness and enthusiasm to engage in the lessons across both individual and group activities.

Numerous studies within the related literature have evidenced the positive impact of flipped learning on student participation in math courses in various educational levels (Cevikbas & Kaiser; 2022; Durong et al., 2018; Kaya, 2018; Kavaz & Kocak, 2024; Lo & Hew, 2021; Love et al., 2014; Egara & Mosimege, 2023; For instance, Kaya (2018) found that flipped learning significantly increased student participation in mathematics lessons. Similarly, the results conducted by Cevikbas and Kaiser (2022) indicate that flipped learning can positively influence students' engagement by enhancing their social interactions and promoting active learning. Egara and Mosimege (2023) found that students exhibited greater interest in mathematics during flipped learning lessons compared to those taught using traditional methods. The findings of the study conducted by Durong et al. (2018) indicate that flipped learning is effective in enhancing student participation and satisfaction in mathematics education. In the meta-analysis conducted by Lo and Hew (2021), the findings suggest that the implementation of flipped learning may enhance various dimensions of student engagement, including behavioral, emotional, and cognitive engagement. Considering these findings, it can be asserted that the results obtained in this study are consistent with the existing literature.

The study revealed that students demonstrated a more positive attitude toward mathematics as a consequence of the implementation of flipped learning. Other studies in the literature also demonstrate that flipped learning engenders a positive shift in students' attitudes toward mathematics lessons (Egara & Mosimege, 2024; Graziano et al., 2017; Kavaz & Kocak, 2024; Muir & Geiger, 2016). The qualitative findings indicate that, overall, students perceived flipped learning as both valuable and engaging.

Through the implementation of this model, thestudents enhanced their comprehension of the subject matter by actively participating in the classroom learning activities rather than merely memorizing information. Similarly, other studies asserted that flipped learning in mathematics courses positively influences students' learning processes (Lo & Hew, 2017; Yorganci, 2022). Flipped learning has enhanced motivation among primary school students by granting them greater responsibility for their learning processes and involving their parents in this endeavour. Other studies also determined that students assumed a more responsible role in their own learning (Esperanza et al., 2023; Lo & Hew, 2017; Mosher, 2016; Toh et al., 2017). This educational model has also established a new paradigm by transforming the role of the teacher from a mere transmitter of knowledge to that of a learning facilitator.

Notably, competitive activities were identified as instrumental in fostering increased interest and participation in mathematics lessons, thereby rendering the learning process more effective and efficient. In the literature, various studies can be found that support the findings of this study. Similarly, Genc and Aydin (2023) found that students' learning beliefs and motivation significantly improved in mathematics lessons taught using flipped learning integrated with educational games.

The incorporation of videos and the use of various platforms, such as EBA and YouTube, were positively received by students as they facilitated the learning process. The availability of multiple platforms afforded students greater flexibility and choice in their educational journey, allowing them to adopt a learning approach that best suited their individual needs. Videos addressed the diverse learning styles of students,

enabling them to comprehend the topics more effectively. Additionally, the capacity to rewatch the videos and take notes concurrently provided students with the opportunity to reinforce their understanding and address any areas in which they required further proficiency.

Throughout the study, it became evident that the quality of the videos utilized in flipped learning was pivotal. Students expressed significant attention to the voice and physical appearance of the instructor in these videos. Conversely, access to technology emerged as a challenge for students during the implementation of flipped learning; therefore, the lack of technological access can be considered a hindrance to the successful execution of flipped learning.

IMPLICATIONS

In this study, the activities employed in the learning process hold significant importance. Within this context, it is recommended that flipped learning incorporate competitive elements, Web 2.0 applications, collaborative group studies, and activities utilizing physical materials into its implementation. It is imperative to design activities that facilitate active student participation, address diverse learning styles, and incorporate a variety of materials. Moreover, fostering student interaction through methods such as collaborative group work, discussion activities, and project-based learning is vital.

The course videos utilized in this study were sourced from both the EBA and YouTube platforms. The development and dissemination of high-quality, current educational materials such as educational videos and interactive applications appropriate for flipped learning is necessary for the utilization by both teachers and students. In this regard, the creation of effective and comprehensible educational videos that align with the interests and learning levels of students is of significant importance. Additionally, it is crucial to provide the requisite technological infrastructure including internet access, computers, and tablets as well as materials necessary for the successful implementation of flipped learning in educational institutions. For students lacking internet access at home, opportunities for video viewing can be established within the school environment, or alternative formats (e.g., audio files) can be made available.

Strengthening communication between parents and teachers is essential to ensure students actively engage with lesson videos. Research should be conducted to educate parents about flipped learning and to encourage their active involvement in their children's educational experiences. In addition, to effectively implement flipped learning, it is essential to enhance in-service training programs and communicate the foundational principles of this pedagogical approach to educators.

LIMITATIONS

The research findings indicate that flipped learning demonstrates considerable potential within the educational sector. However, further investigation is required to augment the effectiveness of this model and to attain more comprehensive outcomes.

The participants in this study are restricted to third-grade students from a single public school in Yozgat, Turkiye. This limitation may affect the generalizability of the findings to other contexts or age groups. Future research could benefit from a more diverse participant pool that encompasses various regions and educational settings. Similar investigations could be conducted in schools located within urban city centres.

Although the scale used in this study dates back to 2005, more recent validated instruments for assessing mathematics anxiety in primary school students in the local context are limited. Future research may benefit from the development or adaptation of updated tools that reflect current curricular and pedagogical shifts.

In this particular investigation, the embedded mixed-methods design was employed as the primary research methodology, which precluded the inclusion of a control group. Nonetheless, quasi-experimental designs involving both control and experimental groups could be implemented in future research. By conducting a comparative analysis of flipped learning and other pedagogical approaches, it is possible to ascertain the relative effectiveness of each method in various contexts. The study involved a limited number of participants (n = 10), which restricts the generalizability of the findings. Therefore, the results should be interpreted with caution and considered exploratory. The duration of the application period for this study was eight weeks,

encompassing a total of sixteen hours. Subsequent studies are essential to examine the long-term effects of flipped learning on students' academic achievement and their levels. Through a comprehensive analysis of students' opinions, it is possible to identify the aspects of flipped learning that are most valued by students, as well as those that require enhancement. Also, the impact of various variables, including students' socio-economic status, gender, and learning difficulties, on the effects of flipped learning warrants examination. By gathering the perspectives of teachers regarding flipped learning, it becomes possible to identify the challenges faced during its implementation and to formulate potential solutions.

BIODATA and CONTACT ADDRESSES of AUTHORS

Yusuf KARAKOC completed his undergraduate studies in the Department of Classroom Teaching at Erciyes University Faculty of Education. He holds a master's degree in Classroom Education from the Department of Educational Sciences at Yozgat Bozok University. This is his first published article. He continues his career as a school principal. Academically, his interests lie in technology, coding, distance education, and educational sciences.

Yusuf KARAKOC
Department of Educational Sciences, Yozgat Bozok University
Address: Uzunlu Ataturk Primary School, 66400, Yozgat, Turkiye
Phone: +905444832973
E-mail: yk.yusufkarakoc@gmail.com

Dr. Kevser HAVA is an Associate Professor in the Department of Elementary Education at Yozgat Bozok University. She received her Ph.D. in Instructional Technology in 2016 from Gazi University. Her research interests include educational game design by students, game-based learning, flipped learning, and technology integration in education.

Kevser HAVA
Department of Elementary Education, Yozgat Bozok University
Address: Faculty of Education, Yozgat Bozok University, 66000, Yozgat, Turkiye.
Phone: +903542421025
E-mail: kevserhava@gmail.com

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APPENDIX A

Mathematics Anxiety Scale for Primary School Students (Bindak, 2005)

	Statement	Always	Often	Occasionally	Almost never	Never
1	When I contemplate mathematics, intricate and often inscrutable concepts arise in my thoughts.					
2	I encounter challenges when attempting to approach the board during mathematics classes.					
3	I consistently experience anxiety about the possibility of being asked questions during mathematics classes.					
4	I have gained an understanding of mathematics at present; however, I am concerned that it may become progressively more challenging.					
5	I possess a heightened apprehension regarding mathematics examinations compared to other academic challenges.					
6	I am concerned that I may not successfully complete my course due to difficulties in mathematics.					
7	Upon entering the mathematics classroom, I experience a profound sense of apprehension that diminishes my confidence.					
8	I am uncertain about the most effective strategies for preparing for mathematics examinations.					
9	Mathematics is a subject that I find highly enjoyable.					
10	I experience apprehension when it comes to posing questions during mathematics class.					

APPENDIX B

Class Participation Observation Instrument

Student Name Surname	Arriving to class punctually	Raising hand during a classroom setting	Demonstrating a willingness and interest in the lesson	Completing responsibilities in event management	Total Points

APPENDIX C

Student Interview Form

1. What are your impressions regarding the lecture videos? What activities did you engage in while viewing the course videos outside of the classroom? Did you encounter any challenges?
2. Have you successfully completed all of your assignments in the class? Did you face any difficulties while carrying out these tasks?
3. What is your opinion on the practice of watching course videos outside of the classroom and focusing solely on in-class activities?
4. How do you evaluate the activities conducted in the mathematics class? Which activities did you find most enjoyable? Which activities were your least favourite?
5. How did the practice of watching lesson videos outside of the classroom and exclusively engaging in in-class activities influence your perception of mathematics?
6. Would you be interested in implementing this type of approach to other subjects within your mathematics course?