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The Effect of Flipped Classroom-Based Instruction on Metacognitive Awareness, Self-Concept, and Self-Efficacy in the Fifth-Grade Mathematics Curriculum

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A B S T R A C T

Purpose: The present study aimed to investigate the effect of flipped classroom-based instruction on metacognitive awareness, self-concept, and mathematics curriculum self-efficacy among fifth-grade elementary school students in Islamabad-e Gharb County.

Methodology: In terms of purpose, this study was applied research, and regarding the method of implementation, it employed a quasi-experimental design with a pretest–posttest control group design. The statistical population consisted of all fifth-grade elementary school students in Islamabad-e Gharb County, totaling 1,684 students during the 2024–2025 academic year. Using an convenience sampling method, 32 students were selected as the sample and were randomly assigned to the experimental group (16 students) and the control group (16 students). Data collection instruments included the Metacognitive Awareness Questionnaire developed by Bako et al., the Mathematics Self-Efficacy Questionnaire by Middleton and Midgley (1997), and the Mathematics Self-Concept Scale by Marsh, SDQ (1983). Data were analyzed using one-way analysis of covariance (ANCOVA) in SPSS software.

Findings: The findings indicated that the metacognitive awareness of students who received instruction through the flipped classroom method increased significantly compared to the control group (Sig = 0.001, F = 137.42). Furthermore, the mean posttest scores of self-concept in mathematics in the experimental group were significantly higher than those of the control group (Sig = 0.001, F = 528.106). In addition, self-efficacy increased in the experimental group compared to the control group (Sig = 0.001, F = 13.782).

Conclusion: Overall, it can be concluded that flipped classroom-based instruction is effective in enhancing metacognitive awareness, learning self-concept, and self-efficacy in mathematics. Therefore, the application of this instructional model in classroom settings is recommended.

Keywords: *Metacognitive Awareness, Learning Self-Concept, Self-Efficacy, Flipped Classroom*

1. Introduction

The rapid development of educational technologies and the increasing emphasis on student-centered learning approaches have significantly transformed contemporary educational systems. Traditional teacher-centered instruction, which mainly relies on passive transmission of information, has gradually been challenged by innovative instructional methods designed to enhance learners' active engagement, autonomy, and cognitive participation in the learning process. Among these emerging instructional approaches, the flipped classroom model has attracted substantial attention in recent years due to its potential to improve both academic achievement and psychological dimensions of learning (Gao et al., 2025; Ray & Guha, 2025). In the flipped classroom model, direct instruction is transferred outside the classroom through digital content such as videos and online materials, while classroom time is dedicated to collaborative learning activities, problem-solving, interaction, and individualized support. This instructional restructuring enables students to become active participants in their own learning process rather than passive recipients of information (Setyoningrum et al., 2025; Zhang et al., 2024).

The flipped classroom approach is grounded in constructivist learning theory, which emphasizes learners' active construction of knowledge through engagement, reflection, and interaction. In this model, students are encouraged to review educational materials independently before attending class, thereby allowing classroom sessions to focus on deeper conceptual understanding and practical application of knowledge. Such an environment not only promotes meaningful learning but also creates opportunities for learners to develop self-regulated learning skills and metacognitive abilities (Pintrich, 2000; Ray & Guha, 2025). Researchers have argued that the flipped classroom environment supports learners' responsibility for their own educational progress and increases opportunities for active cognitive processing and self-monitoring (Gao et al., 2025; Honelly, 2023).

One of the most important psychological constructs associated with effective learning is metacognitive awareness. Metacognition refers to individuals' awareness and regulation of their cognitive processes, including planning, monitoring, evaluating, and controlling learning activities. Students with higher levels of metacognitive awareness are generally more capable of organizing their learning strategies, solving problems effectively, and adapting to academic challenges (Kuhen, 2000; Pintrich, 2000). Metacognitive awareness plays a particularly important role in mathematics education because mathematical problem-solving requires strategic thinking, self-monitoring, and continuous evaluation of cognitive performance. Learners who possess stronger metacognitive skills are more likely to understand mathematical concepts deeply and perform successfully in academic tasks (Bright et al., 2023; Vahidi & Pooshaneh, 2019).

The flipped classroom model may provide favorable conditions for the enhancement of metacognitive awareness because it shifts responsibility for initial learning to students and requires them to engage actively with instructional materials before classroom participation. In such environments, students are expected to monitor their understanding, identify areas of confusion, and regulate their own learning pace. Classroom activities subsequently reinforce these processes through discussion, collaboration, and feedback. Previous research has demonstrated positive relationships between flipped instruction and metacognitive skill development. For example, Vahidi and Pooshaneh reported that flipped classroom instruction significantly improved students' metacognitive skills and academic motivation (Vahidi & Pooshaneh, 2019). Similarly, Kansizoglu and Comert found that flipped writing instruction enhanced metacognitive writing awareness among middle school students (Kansizoglu & Comert, 2020). Honelly also demonstrated that flipped classroom environments positively affected students' metacognitive awareness and self-efficacy in chemistry education (Honelly, 2023). These findings suggest that flipped learning environments may strengthen learners' awareness and regulation of their cognitive processes across various educational contexts.

Another important variable associated with academic success is self-concept, particularly mathematics self-concept. Self-concept refers to individuals' perceptions, beliefs, and evaluations regarding their own abilities and competencies in a specific domain. Mathematics self-concept specifically reflects students' perceptions of their mathematical abilities and competence in mathematics-related tasks. Students with positive mathematical self-concepts tend to exhibit greater persistence, confidence, and motivation in mathematical learning activities (Kaskens et al., 2020; Szumski & Karwowski, 2019). In contrast, students with weak mathematical self-concepts often experience anxiety, avoidance behaviors, and lower academic performance in mathematics.

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The classroom environment and instructional methods play crucial roles in shaping students' academic self-concept. Supportive, interactive, and student-centered learning environments can increase learners' sense of competence and achievement. The flipped classroom model may contribute positively to students' mathematical self-concept because it allows learners to review materials at their own pace, participate actively during classroom sessions, and receive immediate feedback from teachers and peers. Through these processes, students may develop stronger confidence in their mathematical capabilities and experience greater academic satisfaction (Ahmadi et al., 2023; Bright et al., 2023). Ahmadi et al. demonstrated that flipped learning significantly improved elementary school students' self-esteem (Ahmadi et al., 2023). Similarly, Haji Hosseinloo et al. found that cooperative learning methods positively affected students' mathematical self-efficacy and mathematical self-concept (Haji Hosseinloo et al., 2017). Szumski and Karwowski also emphasized the importance of academic self-concept in predicting students' mathematical achievement and educational outcomes (Szumski & Karwowski, 2019).

Closely related to self-concept is the construct of self-efficacy, which refers to individuals' beliefs regarding their capability to organize and execute actions required to achieve desired outcomes. Mathematics self-efficacy specifically reflects students' beliefs in their ability to successfully perform mathematical tasks and solve mathematical problems. Self-efficacy is considered one of the strongest predictors of academic performance, motivation, persistence, and emotional adjustment in educational settings (Karamzadeh et al., 2010; Kaskens et al., 2020). Students with high mathematics self-efficacy are more likely to engage actively in learning activities, persist in the face of difficulties, and demonstrate resilience during challenging academic tasks.

The flipped classroom environment may enhance self-efficacy by increasing students' opportunities for mastery experiences, independent learning, and collaborative engagement. Because students can repeatedly review instructional content before class, they may experience greater comprehension and preparedness during classroom activities. Such experiences can strengthen learners' confidence in their abilities and reduce academic anxiety. In addition, interactive classroom activities characteristic of flipped learning environments provide opportunities for social support, peer interaction, and teacher guidance, all of which contribute to stronger self-efficacy beliefs (Gao et al., 2025; Setyoningrum et al., 2025). Previous studies have supported this assumption. Honelly reported that flipped classroom instruction significantly improved students' self-efficacy and academic achievement (Honelly, 2023). Furthermore, Karamzadeh et al. found that mathematical self-efficacy was a significant predictor of mathematics performance among high school students (Karamzadeh et al., 2010). Kaskens et al. also emphasized that mathematics self-efficacy and mathematics self-concept significantly influence students' mathematical development and educational progress (Kaskens et al., 2020).

Mathematics is widely recognized as one of the most challenging and cognitively demanding subjects in elementary education. Many elementary school students experience difficulties in understanding mathematical concepts and often develop negative attitudes, low confidence, and weak motivation toward mathematics learning. These psychological challenges may subsequently influence students' academic achievement and long-term educational development. Therefore, educational researchers and practitioners have increasingly emphasized the importance of identifying instructional methods capable of improving both cognitive and affective dimensions of mathematics learning (Bright et al., 2023; Karamzadeh et al., 2010). Student-centered instructional approaches such as flipped learning may provide effective solutions to these challenges by fostering engagement, autonomy, self-regulation, and psychological empowerment among learners.

Several studies conducted in educational settings have demonstrated the positive effects of flipped classroom instruction on various academic and psychological outcomes. Kiahosseini and Aslani reported that flipped classroom instruction enhanced academic achievement motivation among elementary school students (Kiahosseini & Aslani, 2015). Moeinikia et al. found that flipped instruction improved elementary students' academic motivation in mathematics (Moeinikia et al., 2021). Ahmadabadi et al. also demonstrated that flipped teaching methods reduced students' shyness and promoted more active classroom participation (Ahmadabadi et al., 2020). Bright et al. concluded that flipped classroom instruction contributed significantly to the development of cognitive skills in mathematics among secondary school students (Bright et al., 2023). In addition, Jooshqan Nejad found that flipped instruction positively affected students' readiness for learning, self-direction, academic motivation, and learning performance (Jooshqan Nejad, 2016).

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Despite the growing body of literature supporting the effectiveness of flipped classroom instruction, relatively limited research has simultaneously examined its impact on metacognitive awareness, mathematics self-concept, and mathematics self-efficacy among elementary school students, particularly within the context of mathematics education. Most existing studies have focused primarily on academic achievement or isolated psychological variables, while fewer studies have explored the combined influence of flipped instruction on these interrelated cognitive and affective constructs. Furthermore, because elementary school years represent a critical developmental period for shaping students' learning attitudes, self-perceptions, and cognitive strategies, investigating the effects of innovative instructional approaches during this stage is particularly important (Kuhen, 2000; Pintrich, 2000).

Given the importance of metacognitive awareness, self-concept, and self-efficacy in mathematics learning, as well as the increasing relevance of flipped classroom approaches in contemporary education, the present study sought to investigate the effect of flipped classroom-based instruction on metacognitive awareness, mathematics self-concept, and mathematics self-efficacy among fifth-grade elementary school students in Islamabad-e Gharb County.

2. Methods and Materials

2.1. Study Design and Participants

The present study was an applied research project conducted using a quasi-experimental method with a pretest–posttest design and a control group. The statistical population consisted of all fifth-grade elementary school students in Islamabad-e Gharb County during the 2024–2025 academic year. According to official statistics obtained from the Department of Education of Islamabad-e Gharb County, the total number of fifth-grade students was 1,684. Due to the large size of the statistical population and the time-consuming nature of the intervention, convenience sampling was employed to select the participants. A total of 32 students were selected as the study sample and were randomly assigned into two groups, including an experimental group (16 students) and a control group (16 students). Before the implementation of the intervention, both groups completed the pretest questionnaires. The experimental group then received instruction based on the flipped classroom model, whereas the control group continued to receive conventional classroom instruction. After the completion of the intervention sessions, both groups participated in the posttest stage.

2.2. Data Collection Tools

The Metacognitive Awareness Questionnaire developed by Bako et al. (2009) was used to assess students' metacognitive awareness. This instrument is a self-report scale designed for children and adolescents aged 7 to 17 years and was adapted from a previous metacognitive assessment instrument known as the Adolescent Metacognitions Questionnaire-2. The questionnaire contains 24 items scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The instrument consists of four subscales, including positive beliefs about worry (positive meta-worry), negative beliefs about worry (negative meta-worry), superstitious beliefs, punishment and responsibility, and cognitive monitoring or awareness of one's own thoughts. Previous studies have reported satisfactory psychometric properties for the questionnaire. The Cronbach's alpha coefficient for the total score in non-clinical samples was reported as 0.71, while reliability coefficients for the subscales were 0.60 for positive meta-worry, 0.76 for negative meta-worry, 0.58 for superstitious beliefs, punishment and responsibility, and 0.74 for cognitive monitoring, indicating acceptable internal consistency.

Mathematics self-efficacy was measured using the Mathematics Self-Efficacy Questionnaire developed by Middleton and Midgley (1997). This scale consists of four items designed to assess students' beliefs regarding their capability and competence in mathematics learning and performance. The items are scored on a four-point Likert scale ranging from 1 ("strongly disagree") to 4 ("strongly agree"), resulting in a total score ranging from 4 to 16. Higher scores indicate greater levels of mathematics self-efficacy. The reliability of the instrument has been confirmed in previous studies. Middleton and Midgley (1997) reported a Cronbach's alpha coefficient of 0.85 for the scale. In addition, Mohsenpour (2005) reported a reliability coefficient of 0.79, while Haji Hosseinlou et al. (2018) obtained a reliability coefficient of 0.87, demonstrating appropriate internal consistency and reliability for educational research purposes.

The Mathematics Self-Concept Scale derived from the Self-Description Questionnaire (SDQ) developed by Marsh (1983) was used to evaluate students' mathematical self-concept. This instrument was adapted by Jitwa and Muwangi

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from the revised version of Marsh's Self-Description Questionnaire (1990). The scale includes 20 items designed to assess different dimensions of mathematical self-concept, including mathematical abilities and skills, avoidance of mathematics, and enjoyment of mathematics. Responses are scored using a five-point Likert scale. Higher scores reflect a more positive mathematical self-concept. Previous research has confirmed the validity and reliability of the instrument. Saleh Sedghpour et al. (2017) reported that the face validity and content validity of the scale were approved by university experts. Furthermore, Cronbach's alpha coefficients for all dimensions of the questionnaire were reported to be above 0.68, indicating acceptable reliability.

2.3. Intervention

The intervention was implemented based on the flipped classroom instructional model for the experimental group over several instructional sessions in mathematics classes. In this approach, educational content, including instructional videos, digital learning materials, explanations of mathematical concepts, and homework guidance, was provided to students before classroom sessions through electronic media and virtual learning tools. Students were required to review the instructional materials at home before attending class. During classroom sessions, the teacher focused on interactive activities, collaborative problem-solving tasks, group discussions, practical exercises, and individualized feedback rather than direct lecturing. This learner-centered instructional method encouraged active participation, self-directed learning, reflective thinking, and greater student engagement in the learning process. In contrast, the control group received mathematics instruction through conventional teacher-centered methods commonly used in elementary school classrooms. At the conclusion of the intervention period, posttest assessments were administered to both groups to evaluate the effectiveness of the flipped classroom model on metacognitive awareness, mathematics self-concept, and mathematics self-efficacy.

2.4. Data Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including means and standard deviations, were calculated for all study variables. To examine the effectiveness of the flipped classroom intervention on metacognitive awareness, mathematics self-concept, and mathematics self-efficacy while controlling for pretest differences, one-way analysis of covariance (ANCOVA) was employed. Prior to conducting the inferential analyses, the assumptions of normality, homogeneity of variances, and homogeneity of regression slopes were examined and confirmed. The level of statistical significance for all analyses was set at $p < .05$.

3. Findings and Results

To examine the effectiveness of flipped classroom-based instruction on students' metacognitive awareness, mathematics self-concept, and mathematics self-efficacy, descriptive statistics and inferential analyses were conducted. First, the means and standard deviations of the pretest and posttest scores for the experimental and control groups were calculated. Then, the assumptions required for conducting analysis of covariance (ANCOVA), including homogeneity of regression slopes, were examined. Finally, one-way ANCOVA was used to determine whether significant differences existed between the experimental and control groups after controlling for pretest scores.

Table 1

Descriptive Statistics of Metacognitive Awareness, Mathematics Self-Concept, and Mathematics Self-Efficacy Scores in the Experimental and Control Groups

Variable	Group	Pretest M	Pretest SD	Posttest M	Posttest SD
Metacognitive Awareness	Experimental	71.38	5.42	96.04	2.63
Metacognitive Awareness	Control	70.94	5.17	71.14	2.63
Mathematics Self-Concept	Experimental	37.26	4.81	43.80	0.53
Mathematics Self-Concept	Control	37.11	4.69	35.62	0.53
Mathematics Self-Efficacy	Experimental	10.84	2.14	13.77	0.44
Mathematics Self-Efficacy	Control	10.63	2.09	11.44	0.45

As presented in Table 1, the mean posttest scores of metacognitive awareness, mathematics self-concept, and mathematics self-efficacy in the experimental group were higher than those of the control group. The descriptive

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findings indicate that students who participated in flipped classroom-based instruction demonstrated greater improvement across all dependent variables compared to students who received conventional instruction. In particular, substantial increases were observed in metacognitive awareness and mathematics self-efficacy among students in the experimental group.

Before conducting ANCOVA, the assumptions underlying the analysis were examined. The normality of score distributions was assessed and confirmed using skewness and kurtosis indices. In addition, Levene's test supported the assumption of homogeneity of variances across groups. The homogeneity of regression slopes assumption was also evaluated by examining the interaction between group membership and pretest scores for each dependent variable. The interaction effects for metacognitive awareness (F = 1.768, Sig = 0.194), mathematics self-concept (F = 1.301, Sig = 0.259), and mathematics self-efficacy (F = 3.453, Sig = 0.068) were not statistically significant, indicating that the assumption of homogeneity of regression slopes was satisfied. Therefore, ANCOVA was considered appropriate for analyzing the posttest differences between the experimental and control groups while controlling for pretest scores.

Table 2

Results of One-Way Analysis of Covariance (ANCOVA) for Metacognitive Awareness, Mathematics Self-Concept, and Mathematics Self-Efficacy

Variable	Source	SS	df	MS	F	Sig
Metacognitive Awareness	Group	4414.376	1	4414.376	42.137	0.001
	Pretest	19.071	1	19.071	0.182	0.673
	Error	3038.116	29	104.763	-	-
Mathematics Self-Concept	Group	39.623	1	39.623	106.528	0.001
	Pretest	61.279	1	61.279	0.993	0.323
	Error	3518.354	57	61.726	-	-
Mathematics Self-Efficacy	Group	79.714	1	79.714	13.782	0.001
	Pretest	99.088	1	99.088	17.131	0.001
	Error	323.906	57	5.784	-	-

The results presented in Table 2 demonstrate that, after controlling for pretest scores, significant differences existed between the experimental and control groups in all three dependent variables. Regarding metacognitive awareness, the effect of group membership was statistically significant (F = 42.137, Sig = 0.001), indicating that students who received flipped classroom instruction showed significantly higher levels of metacognitive awareness compared to the control group. Similarly, a significant difference was observed in mathematics self-concept between the two groups (F = 106.528, Sig = 0.001), suggesting that flipped classroom-based instruction positively enhanced students' perceptions of their mathematical abilities and competence. Furthermore, the ANCOVA results revealed a statistically significant effect of the intervention on mathematics self-efficacy (F = 13.782, Sig = 0.001). This finding indicates that students in the experimental group developed stronger beliefs in their mathematical capabilities compared to students in the control group. Overall, the findings support the effectiveness of flipped classroom-based instruction in improving metacognitive awareness, mathematics self-concept, and mathematics self-efficacy among fifth-grade elementary school students.

4. Discussion and Conclusion

The present study aimed to investigate the effect of flipped classroom-based instruction on metacognitive awareness, mathematics self-concept, and mathematics self-efficacy among fifth-grade elementary school students in Islamabad-e Gharb County. The findings demonstrated that students who participated in flipped classroom instruction showed significantly higher levels of metacognitive awareness, mathematics self-concept, and mathematics self-efficacy compared to students who received traditional instruction. These findings indicate that the flipped classroom model can positively influence both the cognitive and psychological dimensions of mathematics learning among elementary school students.

One of the major findings of the study was the significant improvement in metacognitive awareness among students in the experimental group. This result suggests that flipped classroom instruction creates educational conditions that

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encourage students to become more aware of their cognitive processes and learning strategies. In flipped learning environments, students are required to review educational materials independently before classroom participation. This process increases students' responsibility for learning and encourages them to engage in planning, monitoring, evaluating, and regulating their understanding of mathematical concepts. Because classroom time is dedicated to problem-solving activities, discussions, and feedback, students are provided with greater opportunities to reflect on their thinking processes and correct their misunderstandings. Such experiences naturally strengthen metacognitive awareness and self-regulatory abilities (Kuhen, 2000; Pintrich, 2000).

The findings related to metacognitive awareness are consistent with previous studies emphasizing the role of flipped learning in promoting higher-order cognitive skills and self-regulated learning. Vahidi and Pooshaneh found that flipped classroom instruction significantly enhanced students' metacognitive skills and academic motivation (Vahidi & Pooshaneh, 2019). Similarly, Kansizoglu and Comert reported that instruction based on the flipped classroom model improved metacognitive writing awareness among middle school students (Kansizoglu & Comert, 2020). Honelly also demonstrated that flipped classroom environments positively affected students' metacognitive awareness in chemistry education (Honelly, 2023). The consistency between the present findings and earlier studies may be attributed to the learner-centered nature of flipped instruction, which promotes active engagement, independent learning, and cognitive reflection. Unlike traditional classrooms where students often remain passive recipients of information, flipped classrooms encourage learners to monitor their comprehension and actively participate in constructing knowledge.

Another important finding of the study was the significant increase in mathematics self-concept among students who received flipped classroom instruction. Mathematics self-concept refers to students' perceptions and evaluations of their mathematical abilities and competence. The flipped classroom model appears to strengthen students' confidence in mathematics by creating a supportive and participatory learning environment. In traditional teacher-centered classrooms, students often experience anxiety and fear of failure due to limited opportunities for interaction and individualized support. In contrast, flipped learning environments allow students to review instructional materials repeatedly at their own pace before attending class. This flexibility can reduce academic pressure and provide learners with greater preparedness during classroom activities. Consequently, students may experience greater success and satisfaction, which positively influences their self-perceptions and beliefs regarding mathematical competence.

The improvement in mathematics self-concept observed in this study is aligned with findings reported in earlier research. Ahmadi et al. concluded that flipped learning significantly enhanced elementary school students' self-esteem (Ahmadi et al., 2023). Haji Hosseinloo et al. also demonstrated that cooperative learning approaches improved students' mathematical self-concept and self-efficacy (Haji Hosseinloo et al., 2017). Furthermore, Szumski and Karwowski highlighted the important role of academic self-concept in students' mathematical achievement and educational outcomes (Szumski & Karwowski, 2019). The flipped classroom environment may contribute to stronger self-concept because it increases learners' opportunities for active participation, successful task completion, peer interaction, and constructive feedback. When students experience repeated academic success and perceive themselves as capable learners, their self-concept gradually improves.

The results of the present study also revealed that flipped classroom instruction significantly increased students' mathematics self-efficacy. Self-efficacy reflects students' beliefs regarding their capability to successfully perform mathematical tasks and overcome academic challenges. The enhancement of mathematics self-efficacy in the experimental group may be explained by several characteristics of flipped learning environments. First, students in flipped classrooms have greater control over the pace and timing of their learning, which may reduce feelings of helplessness and anxiety. Second, repeated access to instructional content allows students to master concepts more effectively before classroom participation. Third, classroom sessions in flipped learning environments emphasize interaction, collaboration, and guided practice, all of which contribute to positive mastery experiences and stronger confidence in mathematical abilities.

These findings are consistent with previous studies emphasizing the relationship between innovative instructional approaches and self-efficacy development. Honelly found that flipped classroom instruction improved students' self-efficacy and academic achievement (Honelly, 2023). Karamzadeh et al. demonstrated that mathematical self-efficacy plays a significant role in students'

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mathematics performance (Karamzadeh et al., 2010). Kaskens et al. also reported that mathematics self-efficacy significantly influences mathematical development and learning outcomes (Kaskens et al., 2020). The present findings further support the argument that educational environments emphasizing autonomy, active participation, and individualized learning opportunities can strengthen students' beliefs in their academic capabilities.

The positive effects of flipped classroom instruction observed in the current study may also be interpreted through the lens of self-regulated learning theory. According to Pintrich, self-regulated learning involves learners' active control over cognitive, motivational, and behavioral aspects of learning (Pintrich, 2000). The flipped classroom model inherently promotes self-regulated learning because students are expected to manage their learning activities independently before attending classroom sessions. They must decide when and how to study instructional materials, evaluate their understanding, and prepare for classroom participation. These processes can increase learners' sense of autonomy and responsibility, which subsequently influence metacognitive awareness, self-concept, and self-efficacy.

Another explanation for the effectiveness of flipped classroom instruction lies in the increased interaction and collaboration that characterize this educational approach. During classroom sessions, students engage in collaborative activities, peer discussions, and group problem-solving exercises. Such interactions can create a socially supportive learning environment that reduces fear of failure and encourages participation. Ahmadabadi et al. reported that flipped teaching methods reduced students' shyness and promoted more active classroom engagement (Ahmadabadi et al., 2020). Similarly, Jooshqan Nejad found that flipped instruction improved students' readiness for learning, self-direction, and academic motivation (Jooshqan Nejad, 2016). These social and motivational benefits may indirectly contribute to improvements in self-concept and self-efficacy.

The findings of the present study also support the growing body of literature emphasizing the effectiveness of technology-supported instructional methods in mathematics education. Contemporary learners are increasingly familiar with digital technologies and multimedia learning environments. The flipped classroom model takes advantage of these technological opportunities by integrating educational videos, digital resources, and interactive content into the learning process. Setyoningrum et al. emphasized that integrating advanced technological tools into flipped classrooms can significantly enhance students' learning competencies and engagement (Setyoningrum et al., 2025). Gao et al. similarly identified several factors associated with improved learning performance in flipped classrooms, including learner engagement, interaction, and instructional design quality (Gao et al., 2025). Therefore, the effectiveness of flipped instruction may partially result from its compatibility with the learning preferences and technological experiences of contemporary students.

In addition, the current findings align with studies demonstrating that flipped classroom instruction positively influences academic motivation and cognitive development. Kiahosseini and Aslani found that flipped classroom instruction increased academic achievement motivation among elementary students (Kiahosseini & Aslani, 2015). Moeinikia et al. also reported that flipped instruction improved students' academic motivation in mathematics (Moeinikia et al., 2021). Bright et al. concluded that flipped classrooms contributed significantly to the development of cognitive skills in mathematics education (Bright et al., 2023). The enhancement of metacognitive awareness, self-concept, and self-efficacy observed in the present study may therefore reflect broader improvements in students' motivation, engagement, and cognitive involvement in mathematics learning.

Overall, the findings of the present study indicate that flipped classroom-based instruction can serve as an effective educational approach for improving both cognitive and affective dimensions of mathematics learning among elementary school students. By promoting active learning, self-regulation, autonomy, interaction, and technological engagement, flipped instruction creates learning conditions that support students' psychological growth and academic development simultaneously. The present study contributes to the growing literature on flipped learning by demonstrating its effectiveness in enhancing metacognitive awareness, mathematics self-concept, and mathematics self-efficacy within elementary mathematics education.

One of the limitations of the present study was the relatively small sample size and the restriction of participants to fifth-grade elementary school students in a single county, which may limit the generalizability of the findings to other educational contexts and age groups. In addition, the study relied on self-report questionnaires for data collection, which may have been influenced by students' subjective perceptions and response biases. Another limitation was the relatively short duration of the

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intervention, which may not fully reflect the long-term effects of flipped classroom instruction on students' psychological and academic outcomes.

Future research is recommended to examine the effectiveness of flipped classroom instruction in larger and more diverse samples across different educational levels and academic subjects. Researchers may also investigate the long-term effects of flipped learning on students' academic achievement, motivation, critical thinking, and emotional adjustment through longitudinal studies. Furthermore, future studies could compare the effectiveness of flipped classrooms with other innovative instructional approaches and explore the moderating role of variables such as gender, socioeconomic status, digital literacy, and teacher competency in influencing learning outcomes.

From a practical perspective, the findings of this study suggest that educational authorities, curriculum planners, and teachers should consider integrating flipped classroom approaches into mathematics education, particularly at the elementary school level. Providing teachers with professional training in designing and implementing flipped instruction may increase the effectiveness of classroom teaching and enhance students' engagement and psychological development. Schools should also invest in technological infrastructure and digital learning resources to facilitate the successful implementation of flipped learning environments. In addition, encouraging active participation, collaborative learning, and student autonomy in classroom settings may contribute to the improvement of students' metacognitive awareness, self-concept, and self-efficacy in mathematics learning.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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