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The effect of the flipped classroom strategy on motivation to learn mathematics among 9th-grade female students: a quasi-experimental study in Amman

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Introduction: The flipped classroom strategy (FCS) reimagines traditional instruction by shifting lectures and content delivery outside the classroom, enabling face-to-face time for active, collaborative learning. This study investigates the impact of FCS on the motivation to learn mathematics among 9th-grade female students in Wadi Al-Seer, Amman, Jordan, addressing a gap in understanding its effectiveness in this specific demographic.

Methods: Adopting a quasi-experimental design, 61 students from a single public school were randomly assigned to an experimental group (n = 31, receiving FCS) or a control group (n = 30, following a conventional model). A 31-item Mathematics Learning Motivation Scale (MLMS) was administered to both groups before and after a 12-week intervention to assess changes in motivation. Data were analyzed to compare motivation scores between the groups.

Results: The analysis revealed a statistically significant increase in motivation scores for the experimental group (adjusted mean = 4.27) compared to the control group (adjusted mean = 3.11), with an effect size of 81.9% (p = 0.000). These findings demonstrate that FCS substantially enhances students' engagement and motivation in mathematics.

Discussion: The results suggest that FCS is an effective approach for boosting motivation in mathematics learning among the studied population. The study recommends integrating FCS methodologies into teacher training programs and calls for future research to explore its effectiveness across diverse educational contexts to validate and extend these findings.

KEYWORDS

flipped classroom strategy, motivation, mathematics, 9th-grade, female students, Jordan

1 Introduction

Mathematics education in Jordan continues to encounter persistent barriers, such as minimal student engagement and a dependence on conventional instructional methods that seldom stimulate curiosity or analytical thinking (Al-Tweissi, 2020).

Consequently, there is a need for diverse teaching strategies that engage students' interests, increase their motivation, and provide experiences that foster critical thinking, creativity (Mansour and El-Deghaidy, 2021).

In response, educators are increasingly prioritizing technology integration, and contemporary approaches like the flipped classroom strategy (FCS) emerge as a compelling alternative. FCS inverts the customary instructional sequence, requiring learners to access teaching materials—typically video lectures—at home, while classroom time is reserved for collaborative exercises and problem-solving, thus promoting active engagement and learner autonomy (Tawfik and Lilly, 2015).

Additionally, the FCS encourages teamwork, enhances communication skills, and creates a learning environment that nurtures cooperation, mutual respect, and self-confidence. It provides students with a supportive, respectful environment that values their aspirations and promotes a positive outlook toward learning (Triarisanti et al., 2022).

Research across various contexts suggests that FCS can augment student motivation by permitting tempo variation and personalized exploration (Sezer and Esenay, 2022). In Jordan, where TIMSS results indicate persistent underachievement in mathematics (Mullis et al., 2020), the approach has the potential to transform passive, teacher-centered environments into dynamic settings that prioritize learner agency. Central to this transformation is motivation, which, according to self-determination theory (SDT), flourishes when autonomy, competence, and relatedness are fulfilled (Ryan and Deci, 2000). FCS aligns with these motivational prerequisites by granting students the latitude to pace their study, the opportunity to achieve deeper conceptual mastery, and the chance to interact and negotiate understanding during face-to-face sessions.

Several studies have demonstrated that the FCS is a modern educational method that effectively motivates students, grounded in two core principles: electronic content and active learning (Onodipe and Ayadi, 2020; Sandhu et al., 2019). Numerous studies recommend adopting this strategy in mathematics instruction to increase student motivation and engagement (Egara and Mosimege, 2024; Lo and Hew, 2017).

The present inquiry investigates the influence of FCS on motivational levels among 9th-grade female learners in the Wadi Al-Seer district of Amman, aiming to quantify and interpret motivational shifts induced by the strategy.

Focusing on SDT's core principles of autonomy and competence, we posited that learners engaged with FCS will report markedly stronger motivation than peers receiving traditional instruction. We assessed this difference through the Mathematics Learning Motivation Scale (MLMS), applying a threshold of $p \leq 0.05$.

2 Literature review

The educational literature consistently affirms the FCS's potential to enhance teaching and learning. Al Sayed Mohammed Abdul Qader (2023) studied the approach with 8th graders in the Sultanate of Oman, finding that a quasi-experimental design, coupled with an achievement test and the MLMS, yielded significant post-test gains. The experimental group registered both stronger scores and elevated motivation, with a large effect size validating the intervention's impact (Al Sayed Mohammed Abdul Qader, 2023). A parallel study by Al-Maaytah (2022) traced the flipped learning strategy with 10th graders in Jordan. Again using a quasi-experimental framework, achievement and motivation scales signaled superior performance for the experimental cohort on both measures.

Extending the examination to younger learners, Al-Harbi (2021) investigated 4th graders in Saudi Arabia, documenting the FCS's capacity to boost students' motivation and interest in mathematics through a mixed-method analysis.

The present study employed both a questionnaire and a motivation scale to examine student attitudes toward mathematics. Analysis revealed that participants in the flipped classroom segment reported stronger positive attitudes and elevated motivation when compared to those in the traditional control group (Al-Harbi, 2021). Complementing this work, Vang (2017) conducted research in the United States to determine the flipped classroom's influence on mathematics achievement and self-efficacy. Although the research design mirrored that of Al-Harbi, Vang did not identify statistically significant changes in either achievement or self-efficacy, suggesting that the approach may be less effective in specific educational contexts (Vang, 2017). Similarly, Bhagat et al. (2016) evaluated the flipped classroom's role in improving both achievement and motivation among secondary mathematics students. Through a combination of achievement testing and motivation scaling, the authors documented meaningful gains in both dimensions for learners engaged with the FCS (Bhagat et al., 2016).

Muir (2015) adopted a qualitative lens, exploring the perceptions of students and their parents regarding the implementation of flipped classrooms in the mathematics curriculum.

Muir (2015) took a mixed-methods approach combining surveys and interviews and reported that students and parents felt the flipped classroom strengthened their grasp of mathematical ideas, supported self-directed study, and made lesson review more straightforward. In contrast, Saunders (2014) examined the flipped classroom's effect on motivation and academic performance, yet the analysis showed that students in the flipped setting did not outperform their peers in traditional classrooms on tests of achievement or on motivation questionnaires. Johnson (2013) studied the flipped model in the United Kingdom and found that, while learners in the flipped setting submitted a smaller volume of homework than those in conventional classes, they reported a positive view of the flipped approach, expressing enjoyment of the live workshops and a sense of mastery through collaborative problem-solving.

The current research aligns with prior work in using the FCS to teach mathematics and shares the common use of a quasi-experimental design. Most studies, including the current one, utilized the MLMS, though some variations exist. For instance, Al-Harbi (2021) employed a questionnaire to measure students' attitudes toward mathematics, while Vang (2017) focused on self-efficacy. Muir (2015) used both questionnaires and interviews to assess attitudes, and Johnson (2013) employed an attitude questionnaire as well. Despite these methodological differences, most studies found positive outcomes for the flipped classroom in improving motivation and learning in mathematics. However, Vang (2017) did not observe an improvement in self-efficacy, and

Al-Harbi (2021) noted an increase in students' positive attitudes toward mathematics. Muir (2015) study highlighted favorable perceptions from both students and parents about the FCS model.

The current study aims to examine the flipped classroom impact on 9th-grade female students in the Wadi Al-Seer District in Amman (Jordan), a demographic not previously addressed in the literature, particularly in the context of revised mathematics curricula in general education. By addressing a gap in the educational field, the research provides insights into the use of flipped classrooms to improve student motivation and encourage curriculum designers to develop programs that support teachers in creating and engaging technology-based learning materials. This study also aims to promote self-directed learning by effectively integrating technology into mathematics education. Moreover, this research could inspire flipped classroom use across various subjects and grade levels, with MLMS and the teacher's guide serving as valuable resources for further investigations.

2.1 Research hypothesis

Given the research question and problem, the hypothesis is articulated: There are statistically significant differences between the experimental and control groups in the post-application of the MLMS at the significance level of p-value ≤ 0.05.

3 Research terms and definitions

3.1 Flipped classroom strategy

Procedurally, the FCS strategy is an educational approach to reversing the traditional learning environment. It involves teaching students the content of the "Exponential and Radical Expressions" unit in mathematics by providing educational videos, presentations, or images related to the lesson topic, allowing students to review these materials at any time and from any place outside the classroom. In the classroom, students engage in discussions, complete educational tasks, and practice activities and exercises under the teacher's guidance.

3.2 Motivation toward learning

Procedurally, motivation toward learning is defined as the desire of 9th-grade female students to engage with mathematics, discover knowledge independently, enthusiastically complete tasks and activities, and enjoy learning mathematical content. It also involves connecting new knowledge with prior understanding. This is measured by the total score students receive on the MLMS, specifically designed for this study.

4 Methodology

4.1 Research approach

This study employed a quasi-experimental design to assess the effect of the flipped classroom strategy (FCS) on motivation to learn mathematics. Two groups were formed: an experimental group taught using FCS and a control group taught using traditional methods. The design is represented as:

$$EG : O1 \ \times \ O1$$

CG: O1–O1 Where EG = Experimental Group, CG = Control Group, O1 = Mathematics Learning Motivation Scale (pre/post-test), × = FCS intervention, and – = traditional teaching.

4.2 Sample

The sample consisted of 61 9th-grade female students from a single public school in Wadi Al-Seer, Amman, selected purposively based on school cooperation and suitability for implementing FCS. Two classes were assigned as the experimental group (n = 31) and control group (n = 30). Due to the quasi-experimental design, random assignment was not feasible; instead, classes were selected from three available 9th-grade classes with school administration input to ensure comparable student profiles. This non-random assignment and single-gender, single-school sampling limit generalizability to broader populations, such as male students or other regions, but were chosen to control for contextual variables in this exploratory study.

4.3 Preparation of educational material according to FCS

The "Exponential and Radical Expressions" unit from the 9th-grade mathematics textbook was selected, covering topics like multiplying/dividing rational algebraic expressions, adding/subtracting rational expressions, and solving rational equations. Educational materials were developed based on literature reviews (Al-Harbi, 2021; Al-Maaytah, 2022). Instructional videos (5–7 min each) were created using Camtasia, featuring the teacher explaining concepts with examples aligned with the curriculum's learning outcomes. Videos were standardized for clarity, duration, and content coverage, reviewed by two mathematics education experts, and uploaded to a dedicated Google Classroom platform for student access.

4.4 Flipped classroom activities and assessment method

Activities were designed to promote engagement and included group discussions, worksheets, and problem-solving tasks. Standardization was ensured by using a teacher's guide outlining activity objectives, time allocation (e.g., 10 min for discussion, 15 min for group work), and evaluation criteria. In-class sessions involved addressing student questions from videos, facilitating peer collaboration, and assessing understanding through quizzes and exercises. The guide was validated by three experts in mathematics education, and feedback was incorporated to ensure consistency. Students accessed materials via Google Classroom, with usage tracked to confirm engagement.

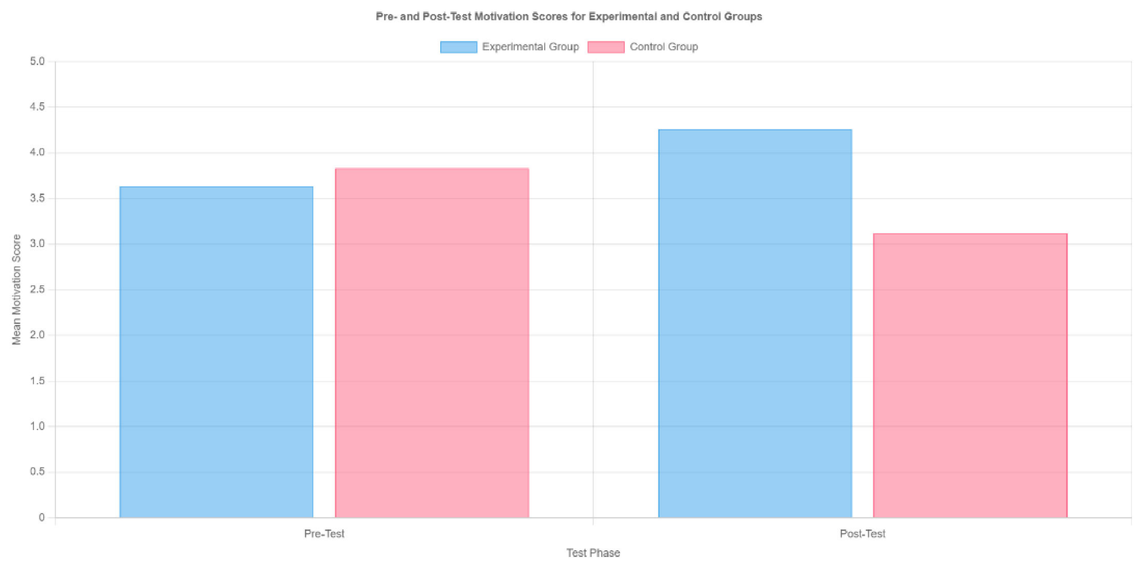

FIGURE 1
Comparison of pre- and post-test mean motivation scores for the experimental and control groups on the Mathematics Learning Motivation Scale (MLMS).

TABLE 1 Difference between the experimental and control groups in the pre-application of the Mathematics Learning Motivation Scale.

Groups	Number	Mean ± SD	*t*-test	df	*P*-value
Experimental	31	3.63 ± 0.43	1.83	59	0.07
Control	30	3.83 ± 0.42			

Df, degree of freedom, statistical significance is at p-value ≤ 0.05.

TABLE 2 Means and standard deviations of the experimental and control groups on the post-application of the motivation scale.

Group	Number	Mean ± SD	Standard error	Adjusted mean
Experimental	31	4.26 ± 0.18	0.03	4.27
Control	30	3.12 ± 0. 34	0.06	3.11

4.5 Research instrument: Mathematics Learning Motivation Scale (MLMS)

A 31-item MLMS was developed based on prior studies (Al-Harbi, 2021; Al Sayed Mohammed Abdul Qader, 2023; Abramovich et al., 2019; Githua and Mwangi, 2003; Izadpanah, 2022), using a five-point Likert scale (5 = strongly agree, 1 = strongly disagree). The scale measured motivation dimensions like enthusiasm, self-efficacy, and engagement.

4.6 Research instrument validity

4.6.1 Face validity

Ten faculty members from Jordanian universities reviewed the initial 33-item MLMS, retaining items with ≥ 85% approval. The final 31-item scale showed item-total correlation coefficients of 0.30–0.81, indicating high internal consistency.

4.6.2 Research instrument reliability

Cronbach's Alpha was 0.85, confirming reliability (Pallant, 2020).

4.7 Research variables

Independent variable: Teaching method (FCS vs. traditional).

Dependent variable: Motivation to learn mathematics (MLMS scores).

4.8 Statistical analysis

Data were analyzed using SPSS v12. Pre-test equivalence was confirmed using a *t*-test. Post-test differences were assessed with means, standard deviations, *t*-tests, ANCOVA, and Eta-squared for effect size.

3 Results

To examine the effect of the flipped classroom strategy (FCS) on motivation to learn mathematics, pre- and post-test scores on the Mathematics Learning Motivation Scale (MLMS) were compared between the experimental and control groups. Figure 1 visually illustrates the differences in mean motivation scores, showing the

TABLE 3 Analysis of Covariance (ANCOVA) results on the post-test of learning motivation toward mathematics.

Source of variance	Sum of squares	df	Mean-squared	F-value	HCP results of the first question language processing -value	Eta-squared
Pre-performance	0.032	1	0.032	263.17	0.00**	0.819
Group	19.273	1	19.273			
Error	4.248	58	0.073			
Total	24.267	60	–			

**P-value ≤ 0.05 indicates statistical significance. df, degree of freedom.

experimental group's improvement post-intervention compared to the control group.

Table 1 shows no statistically significant differences in the pre-test performance of the experimental and control groups on the motivation scale for learning mathematics, with a p-value of 0.07, which is greater than 0.05. This indicates that both groups were equivalent in their motivation to learn mathematics before the implementation of the FCS.

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To address the main research question, what is the effect of using the FCS in developing motivation toward learning mathematics among 9th-grade female students? The means and standard deviations of the student's scores in the experimental and control groups on the post-test motivation scale were calculated, as shown in Table 2.

Table 2 shows clear differences between the means of the experimental and control groups in the post-test application of the motivation scale. The experimental group had a mean score of 4.26 with a standard deviation of 0.18, while the control group had a mean score of 3.12 with a standard deviation of 0.34. To determine whether these differences were statistically significant, an Analysis of Covariance (ANCOVA) was conducted, as displayed in Table 3.

As indicated in Table 3, there is a statistically significant difference between the experimental and control groups in the post-test, with an F-value of 263.17 and a p-value of 0.00, which is significant.

4 Discussion

This study demonstrates that the flipped classroom strategy (FCS) significantly enhances motivation to learn mathematics among 9th-grade female students in Wadi Al-Seer, Amman. Post-test results showed the experimental group's adjusted mean (4.27) was significantly higher than the control group's (3.11), supporting the hypothesis of statistically significant differences (p = 0.000, Table 3). The large effect size (Eta-squared = 0.819) indicates that 81.9% of the variance in motivation scores is attributable to FCS, highlighting its effectiveness.

The Flipped Classroom Strategy likely flourished because it freed class time for hands-on dialogues and worksheets, keeping students animated and involved. By watching topic videos at home, learners set their own pace, which complements self-determination theory's core ideas about feeling in control and feeling capable (Ryan and Deci, 2000). Arriving in class ready to work together meant they could dive straight into solving problems, revisit tricky concepts, and share ideas, all of which fed their motivation (Loucky, 2017; Reddy and Bubonia, 2020). These trends echo earlier research linking FCS to bigger motivation levels (Bhagat et al., 2016; Al-Harbi, 2021).

As a result, students gain confidence, express their opinions more freely, and exhibit greater motivation to engage with mathematics (Akçayır and Akçayır, 2018).

Some studies hint that FCS might sharpen critical thinking (Cevikbas and Kaiser, 2020), but we did not track that directly in this research, meaning those claims still need checking. The rise in motivation we did measure could, in theory, boost skills like problem solving, since students showed more eagerness to face math challenges. Yet this finding runs counter to Vang (2017), who reported no change in self-efficacy, suggesting that FCS works differently depending on the setting or how it is rolled out.

To build on FCS's advantages, educators must learn to craft compelling multimedia content and design interactive lessons. Future studies should test FCS across varied student groups and measure wider outcomes to see how broadly it can apply.

5 Conclusion

The research shows that the Flipped Classroom Strategy raises 9th-grade female students' motivation to learn mathematics in Wadi Al-Seer, Amman. In the experiment, students learning through flipped classroom strategies had a markedly higher adjusted mean motivation rating of 4.27, relative to the control group's 3.11; the strong effect size (Eta-squared = 0.819, p = 0.000) indicates the difference is not due to chance. These results imply that the flipped approach boosts students' enthusiasm for mathematics by permitting individualized pacing alongside communal, interactive tasks.

The data bolster the accumulating research advocating the flipped classroom as a remedy for low motivation in mathematics. Although this inquiry centered solely on motivation, earlier investigations indicate the flipped method can also enhance academic results and self-belief in competence (Bhagat et al., 2016;

Al-Harbi, 2021), outcomes that we did not assess on this occasion. To realize the method's full potential, curricula and teachers must work in concert, supplying captivating materials—such as instructional videos—and nurturing environments that encourage risk-taking and collaboration.

In summary, this research enriches the collective understanding of the flipped classroom and points to useful directions for subsequent investigations. Future work ought to examine the approach's influence on academic achievement and self-efficacy, and to test it in varied groups, including boys, gifted pupils, and students who struggle in mathematics, thereby broadening its relevance across different schooling settings.

5.1 Recommendations

To maximize the flipped classroom's impact on mathematics instruction, the following strategies are advised. To begin, arranging workshops and on-going training for mathematics teachers is crucial for ensuring they are comfortable with the FCS, its methods, and administrative procedures. In tandem, training must prioritize student motivation, providing teachers with effective techniques to cultivate it. Integrating FCS elements into selected mathematics units throughout the curriculum increases student involvement and learning gains. Ultimately, continued investigation into how the FCS affects diverse student populations, including gifted learners and those who are traditionally slow to progress in math, is necessary for grasping its full potential and informing wider implementation.

5.2 Limitations

This study is constrained by a number of factors. Results are drawn from a cohort of female 9th graders attending a single public school in the Wadi Al-Seer District, Amman. The geographical focus is therefore narrow, having been carried out in the second semester of the 2023/2024 academic year. Moreover, the investigation is confined to the chapter on "Exponential and Radical Expressions" in the 9th-grade mathematics textbook, limiting the applicability of the conclusions to different topics or to other educational settings.

Data availability statement

The original contributions presented in this study are included in this article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. All participants in this study provided their informed consent before participation. They were fully informed about the study's purpose, procedures, potential risks, and benefits, as well as their right to withdraw at any time without penalty. Written consent was obtained from each participant, and all data were collected and handled under ethical guidelines to ensure confidentiality and anonymity. The participant's legal guardian/next of kin provided written informed consent to participate in this study.

Author contributions

OM: Writing – original draft, Writing – review & editing, Software, Validation. YW: Writing – original draft, Writing – review & editing, Conceptualization, Data curation.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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