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Research Paper

Improving the Students' Data Management Skills through Flipped Classroom

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Abstract

The Philippines continues to face educational challenges, as reflected in the 2018 PISA results, which show low performance in reading, science, and mathematics. Limited resources, large class sizes, and high student–teacher ratios contribute to students' disengagement, particularly in mathematics. To address this issue, the study examined the effectiveness of the flipped classroom approach, a strategy that promotes active student participation in improving college students' data management skills in mathematics. Using a quantitative pre-experimental design, 27 students completed pretest and posttest assessments, which were analyzed using means, standard deviations, and paired t-tests. Results revealed significant improvement in posttest scores, indicating that the flipped classroom enhances engagement and academic performance in data management. Although limited by a small sample size and narrow focus, the study provides evidence that the flipped classroom can be an effective solution to improve mathematics learning in resource-constrained educational contexts.

Keywords *Flipped Classroom; Data Management; Teaching Strategy*

INTRODUCTION

In 2018, the Philippines participated in the Program for International Student Assessment (PISA) for the first time, revealing alarming results. The country ranked at the bottom in reading and second-to-last in science and mathematics among the 79 participating countries and economies. PISA assesses the abilities of 15-year-old students in reading, mathematics, and science, evaluating their application of essential knowledge and skills. Notably, over 78 percent of Filipino students failed to meet the minimum competency levels in all three domains, underscoring the urgent need to strengthen the quality of education in the country.

According to the World Bank (2020), one of the key reasons behind this poor performance is insufficient investment in financial, human, and digital learning resources, especially in disadvantaged schools. With the lowest per-student spending among participating nations, the Philippines faces challenges such as overcrowded classrooms and high student–teacher ratios, which negatively affect students' learning experiences. Interestingly, the study also revealed that teacher qualifications alone were not a strong predictor of student performance, suggesting that the quality of instructional practices and the learning environment play a more crucial role.

Alenezi (2017) emphasized the transformative potential of educational technology, highlighting its ability to redefine teachers' roles from mere transmitters of knowledge to facilitators of learning. In the same vein, Adipat et al. (2021) stressed that twenty-first-century education must integrate tools that improve teaching efficiency and learning engagement. However, while numerous studies confirm the promise of technology integration, a gap remains in understanding how specific pedagogical models, such as the flipped classroom, can be effectively adapted within the Philippine context, particularly in mathematics education, where digital inequity and traditional instruction remain prevalent.

Traditional teaching methods, as noted by Bahroun et al. (2023), often encourage rote memorization rather than conceptual understanding, leaving students disengaged and ill-equipped

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to apply mathematical knowledge in real-world situations. This theoretical gap points to the need for instructional designs that promote active, student-centered learning, consistent with constructivist and experiential learning theories. The flipped classroom approach aligns with these frameworks by shifting direct instruction outside the classroom and dedicating in-class time to higher-order cognitive activities, discussion, problem-solving, and application.

The integration of technology in mathematics education has been recognized globally as a catalyst for deeper learning. Fabian et al. (2018) cited the Curriculum for Excellence in Scotland, which promotes the "appropriate and effective use of technology" to enhance enjoyment and understanding in mathematics. Similarly, Tondeur et al. (2017) reported that technology-supported instruction significantly improves mathematics achievement compared to traditional methods. Digital platforms such as Desmos, Miro Whiteboard, Kahoot!, and Padlet further facilitate interaction, collaboration, and engagement (Samaila et al., 2021).

Despite these global insights, there remains a lack of empirical evidence in the Philippines on how the flipped classroom approach can enhance students' mathematical understanding, engagement, and data management skills, a critical aspect of modern quantitative literacy. Thus, this study addresses both a theoretical and practical gap: theoretically, it tests the flipped classroom model within the context of the constructivist and active learning paradigms; practically, it offers an innovative instructional design framework suitable for resource-constrained educational contexts. The study contributes to pedagogical theory by demonstrating how student-centered, technology-enhanced instruction can foster deeper mathematical comprehension and learner autonomy, and to instructional design by providing a model adaptable to similar developing-country settings seeking to improve mathematics outcomes.

LITERATURE REVIEW

This literature review is organized around major themes related to the teaching of mathematics through the flipped classroom approach, highlighting the theoretical and empirical bases of the study. It synthesizes key findings and establishes the pedagogical and instructional gap that this research aims to address.

Mathematics Education in the Philippines

Mathematics education in the Philippines continues to face significant challenges, as evidenced by the consistently low student achievement in international assessments, such as the Third International Mathematics and Science Study (TIMSS) in 2003 and 2019. Filipino students ranked among the lowest globally, with scores indicating persistent weaknesses in mathematical comprehension and problem-solving. Despite efforts to improve the curriculum through the K to 12 Basic Education Program, students still perceive mathematics as a difficult subject, often leading to low motivation and engagement.

Scholars such as Ozdamli and Asiksoy (2016) have noted that the rapid shift toward online and flexible learning—accelerated by the COVID-19 pandemic— has transformed students into "digital natives" with distinct learning preferences and higher expectations for interactive instruction. This shift challenges teachers to adopt strategies that promote active participation and student motivation. Both Bennett and Szedlak (2023) emphasized that innovative, technology-supported pedagogies are essential for sustaining quality education in the post-pandemic era.

When viewed collectively, these studies reveal a progression from content-focused to learner-centered education. However, most reforms in Philippine mathematics instruction remain confined to surface-level curriculum adjustments rather than rethinking the instructional design itself. This gap underscores the need for approaches that operationalize constructivist principles—allowing learners to construct knowledge actively through engagement, collaboration, and reflection.

Flipped Classroom Approach: Theoretical and Pedagogical Basis

The flipped classroom model, also called the inverted classroom, redefines traditional instruction by assigning direct content delivery (e.g., lectures, readings, or videos) as homework, while classroom time is used for application, collaboration, and higher-order thinking (Bishop & Verleger, 2013; Hamdan et al., 2013). This approach is grounded in constructivist learning theory, which posits that learners construct their understanding through active engagement with content and peers (Ozdamlı & Aşıksoy, 2016). Within this framework, the teacher acts as a facilitator rather than a transmitter of knowledge, guiding learners through inquiry and problem-solving.

Empirical studies (Gilboy et al., 2014; Shih & Tsai, 2017) consistently demonstrate that flipped classrooms improve student motivation and foster deep learning by integrating active learning strategies such as problem-based learning, think-pair-share, and collaborative projects. Similarly, local research (Calamlam, 2016; Segumpan & Tan, 2018; Cagande & Jugar, 2018; Malto et al., 2018) provides strong evidence that the flipped classroom enhances performance in mathematics and science subjects across educational levels.

The synthesis of international and local findings reveals a convergence of results: technology-supported, student-centered approaches lead to greater engagement and achievement. However, there remains limited exploration of how the flipped classroom specifically enhances data management and analytical skills in college-level mathematics—skills essential for 21st-century learners.

Technology-Based Mathematics Instruction

Technology integration in mathematics instruction has long been recognized as a catalyst for educational innovation. Bennett and Szedlak (2023) argued that outdated, teacher-centered methods diminish motivation, while Nicolaidou et al. (2022) and Alenezi (2017) showed that digital tools promote engagement, self-paced learning, and collaboration—core features of the flipped classroom model. Technology not only supports differentiated instruction but also facilitates experiential and social learning, aligning with Bandura's social learning theory and Kolb's experiential learning cycle, both of which emphasize learning through interaction, feedback, and reflection.

Studies (Dove & Dove, 2017; Roehl et al., 2013; Gilboy et al., 2015) further demonstrate that flipped learning encourages autonomy and mastery by allowing students to revisit content at their own pace. This personalized learning experience helps bridge performance gaps among diverse learners and nurtures essential skills, such as decision-making, collaboration, and problem-solving.

When synthesized, these studies point toward a paradigm shift in mathematics education—from rote, procedural learning to active, technology-enhanced learning. Yet, few empirical investigations in the Philippine context have systematically examined the effectiveness of the flipped classroom in improving data management competencies in mathematics, particularly among college students.

Synthesis

Overall, the reviewed literature consistently supports the implementation of active, learner-centered, and technology-integrated pedagogies in mathematics education. Both international and local studies have demonstrated that the flipped classroom approach enhances students' motivation, engagement, and academic performance. This convergence of evidence highlights the model's effectiveness in promoting meaningful learning experiences through active participation and the integration of digital tools. However, despite these promising findings, a clear theoretical and practical gap remains unaddressed.

From a theoretical standpoint, limited research has explored how the flipped classroom

model aligns with established instructional design frameworks such as constructivism, experiential learning, and social learning theory, particularly within the Philippine higher education context. These frameworks emphasize active knowledge construction, experiential engagement, and social interaction as essential elements of learning—principles that are central to the flipped classroom but often not explicitly linked in existing studies. Establishing this connection is vital to deepening the theoretical grounding of flipped learning and advancing its integration into formal pedagogical models.

From a practical perspective, while prior studies affirm the general benefits of the flipped classroom in improving academic outcomes, there is still a lack of focus on its specific impact on developing data management skills—a key component of mathematical literacy and analytical thinking in the digital era. Given the growing importance of data-driven problem-solving and decision-making in education and the workplace, exploring how the flipped classroom enhances these competencies is both timely and necessary.

This study seeks to bridge these theoretical and practical gaps by employing the flipped classroom model as both a pedagogical strategy and an instructional design framework to improve students' engagement and data management competencies in mathematics. Grounded in constructivist and experiential learning theories, the research not only contributes to pedagogical theory but also advances instructional innovation. Ultimately, it aims to enrich the broader discourse on transforming mathematics education, particularly in resource-constrained learning environments such as those found in the Philippines.

RESEARCH METHOD

This section presents the methodological framework of the study, encompassing the research design, respondents and sampling procedures, research instruments, data collection, data analysis, and ethical considerations. Each component was carefully designed to ensure the reliability, validity, and ethical integrity of the research process in evaluating the effectiveness of the flipped classroom approach in enhancing students' data management skills in mathematics.

The study utilized a quantitative pre-experimental one-group pretest–posttest design, which allowed for measuring the change in students' performance before and after the implementation of the flipped classroom intervention. This design was deemed appropriate because it enabled the researcher to determine whether any significant improvement occurred following the teaching intervention (Nachmias & Nachmias, 2004). The research procedure followed a clear sequence of activities: (1) pretest administration, (2) flipped classroom intervention, (3) posttest administration, (4) survey feedback, and (5) data analysis. This systematic flow ensured accurate assessment of learning gains and the collection of comprehensive data for analysis. The quantitative approach was selected for its ability to analyze numerical data and determine statistical relationships, means, and significance levels (Cint, 2020).

The study participants consisted of twenty-seven (n = 27) first-year Bachelor of Secondary Education (BSED) major in Filipino students enrolled in Mathematics in the Modern World at the Laguna State Polytechnic University – Los Baños Campus, under the College of Teacher Education during the academic year 2023–2024. Purposive sampling was employed since the participants met specific inclusion criteria; they had already completed Statistics and Probability in senior high school, which ensured that they possessed the foundational knowledge necessary for learning data management concepts in college (Tondeur et al., 2017). The sample size was justified based on the total population of students enrolled in the course section, making it a complete group suitable for a pre-experimental design. Furthermore, given that this class represented a typical group of college students studying mathematics in a teacher education program, the findings are contextually meaningful for similar learning environments.

Two instruments were used for data collection. The first instrument was a 25-item multiple-choice achievement test adopted from a previous study, which assessed students' understanding of data management concepts, particularly Random Variables and Probability Distributions. The test was adapted from the Department of Education's Statistics and Probability Curriculum Guide and validated instruments from similar studies in mathematics education (Cheung & Slavin, 2013; Fabian et al., 2018). The items measured cognitive performance aligned with the intended learning competencies. Prior to administration, the instrument underwent expert validation by five (5) mathematics educators to ensure content and face validity, resulting in a Content Validity Index (CVI) of 0.94, which indicated excellent agreement among validators. The test also underwent pilot testing among fifteen (15) non-participating students to determine its internal consistency, producing a Cronbach's alpha coefficient of 0.89, which signifies high reliability according to George & Mallery's (2019) thresholds.

The second instrument was a researcher-made survey questionnaire developed to assess students' perceptions of the flipped classroom strategy. The survey focused on four major domains: engagement, motivation, satisfaction, and perceived learning effectiveness. Items were formulated based on themes from prior flipped learning research (Ozdamlı & Aşıksoy, 2016; Samaila et al., 2021) and tailored to fit the local educational context of the university. The instrument was reviewed by a panel of experts in educational research and technology integration to establish construct and face validity. It was then pilot-tested on a separate group of pre-service teachers, yielding a Cronbach's alpha value of 0.86, indicating good reliability and internal consistency.

The data collection procedure followed an organized and ethical process. After securing formal approval from the Associate Dean of the College of Teacher Education and the research adviser, as well as consent from the expert validators, the researcher began data gathering. The pretest was first administered to measure students' baseline performance in data management. This was followed by the implementation of the flipped classroom intervention, which lasted for five weeks (Weeks 6 to 10 of the first semester of the 2023–2024 academic year). During this period, students engaged with pre-recorded video lectures, online materials, and interactive digital resources before class. Classroom sessions were devoted to collaborative discussions, guided exercises, and application-based learning activities that reinforced data management concepts. After the intervention, the posttest was administered to measure learning gains, followed by the researcher-made survey, which collected students' feedback and perceptions regarding the flipped classroom experience.

Upon completion of data collection, results were tabulated using Microsoft Excel and then imported into IBM SPSS Statistics Version 25 for analysis. Descriptive statistics, such as the mean and standard deviation, were used to summarize students' performance on the pretest and posttest, as well as their survey responses. Inferential statistics, particularly the paired-sample t-test, were employed to determine whether there was a statistically significant improvement in the students' posttest scores compared to their pretest results. The reliability of instruments was evaluated based on Cronbach's alpha coefficients following the interpretation guidelines by George & Mallery (2019), while the statistical procedures adhered to the analytical framework proposed by Pallant (2020).

Finally, the research strictly adhered to ethical standards throughout its implementation. Formal authorization was obtained from the concerned university authorities, and informed consent was secured from all participants prior to data collection. Ethical principles, including beneficence, non-maleficence, autonomy, and confidentiality, were upheld following the American Psychological Association research ethics guidelines. Participants were informed of the voluntary nature of their involvement, and their responses were treated with strict confidentiality. All data were used solely for academic purposes and securely stored to maintain anonymity. Through these

ethical and methodological safeguards, the study ensured the credibility, validity, and reliability of its findings.

FINDINGS AND DISCUSSION

Table 1 shows pretest mean scores in statistics among the students' respondents.

Table 1. Pretest mean scores in statistics among the students-respondents

Group	Mean	Std. Dev.	Descriptive Interpretation
Experimental Group	14.33	4.91	Low

Legend: 26– 30 = Very High; 21 – 25 = High; 16 – 20= Average; 11-15 – Low; 1 – 10 = Very Low

Table 1 presents that the experimental group had a mean score of 14.33 (SD = 4.91), indicating a low performance level. These findings highlight that before implementing the flipped classroom to improve the data management skills of college students, it is evident that the performance is below average.

According to Gilboy et al. (2014), Flipped classrooms encompass a diverse range of active learning approaches, including problem-based learning, simulations, discussions, and think-pair-share activities. These techniques aim to foster brainstorming, group debates, competitions, hands-on tasks, and presentations, as highlighted by Shih & Tsai (2017). In the context of the Philippines, educators incorporate active learning strategies into their instructional plans, utilizing methods such as group workshops, worksheets, engaging exploratory activities, exercises, and problem-solving tasks.

Table 2 shows posttest mean scores in statistics among the students' respondents.

Table 2. Posttest mean scores in statistics among the students-respondents

Group	Mean	Std. Dev.	Descriptive Interpretation
Experimental Group	22.02	3.52	High

Legend: 26– 30 = Very High; 21 – 25 = High; 16 – 20= Average; 11-15 – Low; 1 – 10 = Very Low

Table 2 shows the experimental group's posttest mean score of 22.02 (SD = 3.52), indicating a high level of interpretation. These findings highlight the effectiveness of using a flipped classroom, as the experimental group significantly improved from their low pretest scores to high posttest scores.

Academic circles generally agree that the flipped classroom paradigm improves students' academic performance, as demonstrated by studies by Gross et al. (2015), Gilboy et al. (2015), and Roehl et al. (2013). The adoption of a student-centered learning approach in the flipped classroom model is largely responsible for this broad recognition. According to Roehl et al. (2013), a fundamental change in the dynamics of instruction gives students the freedom to engage with the information at their own pace. As it accommodates individual learning preferences and gives students the freedom to review and reinforce difficult topics as needed, this personalized learning experience is believed to have a substantial positive impact on better academic achievements. The combined results of this research highlight how the flipped classroom paradigm's emphasis on customized and self-directed learning can have a favorable impact on students' academic attainment.

Table 3 shows the level of perceived effectiveness of Flipped Classroom in improving the data management skills.

Table 3. Level of perceived effectiveness of Flipped Classroom in improving the data management skills

Indicative Statement	Mean	SD	Descriptive Interpretation
1. The flipped classroom approach helps me understand data management easily.	2.67	0.67	High
2. The presentation of the concepts in a flipped classroom is clear and fitted to my needs.	2.63	0.73	High
3. I could easily understand the explanations when flipped classroom is utilized in class.	2.81	0.61	High
4. I learn some useful information not mentioned in the regular teaching after using the flipped classroom approach	2.63	0.48	High
5. The time allotment when using flipped classroom approach is adequate for each lesson.	2.59	0.68	High
6. Activities and tasks given in the flipped classroom approach were very easy.	2.56	0.57	High
7. I enjoyed reading and doing all activities provided in the flipped classroom approach.	2.70	0.66	High
8. When flipped classroom approach is utilized, I am able to understand the words and terms suited to my mathematics literacy.	2.52	0.69	High
9. flipped classroom approach inspired and encouraged me to learn more topics in Data management.	2.56	0.74	High
10. I want to apply flipped classroom approach in a regular classroom teaching next time.	2.70	0.81	High
Composite	**2.64**	**0.45**	**High**

Legend: *1.00 – 1.74 = Very Low; 1.75 – 2.49 = Low; 2.50 – 3.74 = High; 3.75 – 4.0 = Very High*

As shown in Table 3, students generally demonstrate a high perceived effectiveness in enhancing data management skills through the use of the Flipped Classroom, as indicated by a composite mean of 2.64 and a standard deviation of 0.45. The use of a flipped classroom enables learners to understand the various concepts clearly and sequentially that they need to learn mathematics.

This is related to the findings of Samaila et al. (2021) that the flipped classroom is an innovative approach in offering learner-centered courses that is recognized globally as a modern educational strategy focused on improving learning chances for all students within the education system.

Furthermore, student-respondents reported a strong desire to incorporate the Flipped Classroom technique into their traditional classroom training in the future. Their focus on this desire demonstrates an understanding of the method's potential benefits. They also feel that the time allotment when using RAP is adequate for each lesson, since the university practices a hybrid type of learning. This impression indicates that learners believe they can effectively engage with and absorb new topics when delivered through a flipped classroom, since their asynchronous time will be used efficiently, and even when limited in-class time is available. The acceptance of the approach's adaptability and perceived appropriateness of time allocation highlights the potential and appeal of incorporating innovative teaching tactics to improve learning results in a typical classroom context.

Table 4 shows the test of significant difference between the pretest and posttest mean scores of the student-respondents.

Table 4. Test of significant difference between the pretest and posttest mean scores in mathematics of the students

Group	Test	Mean	p-value	t-value	Cohen's d
Experimental	Posttest Pretest	22.07 14.33	.000	-9.036	1.81 (Huge)

*df = 48; *Significant at .05 level; Cohen's d: small (d = 0.2), medium (d = 0.5), large (d = 0.8), very large (1.20), and huge (2.0)*

As shown in Table 4, the pretest and posttest results of the experimental group (t = -9.036) reveal a statistically significant difference, as evidenced by the computed p-value being less than .05. This indicates that the flipped classroom is effective in improving the data management skills of college students. It is also evident that, based on the computed Cohen's d of 1.81, which is interpreted as substantial, the intervention under investigation has a significant impact, making it a noteworthy and potentially influential factor in the observed outcomes.

This relates to the findings of Malabayabas (2023), where he emphasized that representation acts as a tool for communication and manipulation for conceptual understanding of mathematical ideas. When students are able to represent a mathematical situation in a meaningful way, they see that situation as more accessible. Therefore, instructional strategies should focus on helping the students learn through representations so they can generalize ideas and finally interpret them.

The claim made by Gafoor & Sarabi (2015) that a flipped classroom approach can improve students' academic performance in mathematics is based on the assumption that this educational paradigm promotes active learning. By converting traditional lectures to pre-recorded materials that students can review at home, class time is transformed into a chance for hands-on interaction, developing a deeper comprehension of mathematical topics. Furthermore, the flipped classroom concept enhances student satisfaction by allowing them to learn at their own pace and revisit challenging topics as needed. As class time is dedicated to collaborative problem-solving and addressing individual learning requirements, the dynamic interaction between teachers and students is also enhanced.

CONCLUSIONS

This study was conducted to determine the effectiveness of the flipped classroom approach in enhancing students' data management skills and engagement in learning statistics. The specific objectives of the study were to (1) assess the level of students' data management skills before and after the implementation of the flipped classroom model, (2) determine the significant difference between the pretest and posttest scores of the experimental group, and (3) analyze how the flipped classroom approach influences students' engagement and understanding of statistical concepts.

The findings of the study revealed a significant improvement in students' performance after the intervention, indicating that the flipped classroom approach has a positive impact on learning outcomes. The results further suggest that allowing students to access instructional content outside class time enables them to review lessons at their own pace, promoting self-directed learning. Consequently, in-class sessions become more interactive, with students actively participating in discussions, problem-solving activities, and data analysis exercises. This active engagement not only deepens conceptual understanding but also strengthens data management competencies, which are essential for evidence-based decision-making and analytical reasoning in mathematics and related disciplines.

Overall, this study advances the field of mathematics education by providing empirical evidence that the flipped classroom can bridge the gap between theoretical understanding and practical application. By integrating technology, constructivist pedagogy, and experiential learning

principles, the flipped classroom approach creates a learner-centered environment that enhances students' academic performance, critical thinking, and digital literacy. This research contributes to the growing body of literature advocating for innovative instructional models that promote 21st-century skills, particularly in resource-constrained educational settings such as the Philippine higher education context.

LIMITATION & FURTHER RESEARCH

While the results of this study demonstrate the effectiveness of the flipped classroom model, certain limitations must be acknowledged. First, the study was limited to a single experimental group within a single academic institution, which limits the generalizability of the findings to broader populations. Second, the duration of the intervention was relatively short and covered only selected topics in statistics and data management, which may not fully capture long-term learning outcomes. Third, the study primarily relied on quantitative measures through pretest and posttest assessments; therefore, qualitative insights, such as students' perceptions, attitudes, and experiences, were not extensively explored.

Future research may address these limitations by including larger and more diverse samples across various academic programs and institutions. Longitudinal studies are recommended to examine the sustained impact of the flipped classroom approach on students' performance and motivation over time. Moreover, mixed-method or qualitative research designs may be employed to capture deeper perspectives on learner engagement, instructional adaptability, and teacher facilitation. Future studies may also explore the integration of advanced digital tools, such as learning analytics and adaptive technologies, to further enhance the effectiveness of flipped learning environments in mathematics and other STEM disciplines.

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