Research Article

Teaching Strategies and Students' Performance in Mathematics in a Borderless Classroom

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ABSTRACT

As the educational sector shifted from traditional to borderless classrooms, having discussions through virtual platforms became the most popular option to keep the learning going amid the pandemic. This study investigated the teaching strategies of mathematics college instructors in college on the second-year mathematics students' performance in borderless classrooms. It also determined how well the mathematics instructors adjusted to the situation, as evidenced by how and what teaching strategies they used in their classes. Fifteen mathematics instructors were recruited for the study using a random sampling technique. Findings revealed that some teachers were unfamiliar with various tools and platforms. Using the Pearson correlation coefficient, there is a significant positive relationship between the teaching strategies in the borderless classrooms and the student's performance in mathematics r (13) = .49, p< .04. The Strategic Intervention Applied in Asynchronous Teaching (SIAAT) was proposed by which will ensure that students will continue to receive asynchronous learning in borderless classrooms.

Keywords: Borderless classrooms, Students' performance, Teaching strategies, Virtual platforms

Introduction

Teaching strategies are multi-dimensional, and their effects depend on the context in which they are applied, such as in borderless classrooms. Choosing the right teaching strategies is vital for the student's performance (Mitchell, 2014; Morgan, 2014). Using a suitable one that works best for the students can affect how they understand, digest, and absorb the knowledge the teachers distribute. It can be of aid in developing their learning and understanding. Imposing a strategy that would be in line with the matter to be discussed cannot just gain back their interest in the class but also lets them ponder and learn. Maximizing their

learning goals, in a sense, should be evident in their performance.

Before the pandemic, some European countries already employed virtual platforms to teach mathematics (Light & Pierson, 2014; López, 2016). Individual and collaborative learning can be accomplished using e-learning environments. In Italy, frontal teaching, exercises, and personal/group work were the most used teaching methods. Schools typically include a gymnasium, a library, ICT, science, and multimedia laboratories. An increasing number of classrooms now have interactive whiteboards (IWB). Teachers chose textbooks and teaching aids. Teachers can either confirm the books they used the previous year or use new books. In the latter case, textbooks can be digital or hybrid; mixed format means paper, paper plus digital or digital, all with integrated digital content (Doe, 2017).

During school lockdowns in the Philippines, most universities have turned to online learning. However, this abrupt shift has created issues, particularly for students who do not have access to technology. These posed a significant challenge to teachers and students (Anderson et al., 2021; Geverola et al., 2022; Rapanta et al., 2021). Due to access and internet availability, teachers and students have difficulty maintaining academic attention (Dayagbil et al., 2021). Universities and colleges have employed a variety of diverse learning and teaching approaches based on their situations under this new structure.

This study investigates the teaching strategies of mathematics college instructors on second-year mathematics students' performance in borderless classrooms. It determined the profile of the respondents, the extent of use of the teaching strategies in the borderless classrooms, and the significant relationship between the teaching strategies in the borderless classrooms and the student's performance in mathematics.

Related Literature and Studies

Starting each session with a brief lesson review tested students' comprehension and learning (Bart, 2015). Students could absorb the information and remain engaged when mini lectures were mixed with exercises, discussions, and reflection times. Teachers should establish an incredible learning experience for students. Experiential learning, direct instruction, indirect instruction, interactive instruction, and independent study are the five pillars of teaching strategies. Some activities include narratives, demonstrations, case studies, debates, and journals (Texas University, 2014). Heather (2018) pinpointed the best teaching strategies in the classroom, such as visualization, cooperative learning, inquiry-based instruction, differentiation, classroom technology, behavior management, and professional development. Student-centered teaching strategies foster critical thinking skills and polite classrooms (Guzman, 2016; Soubra et al., 2022).

Most educational institutions were affected due to the pandemic. As a result, every institution has adopted an online education model incorporating information communication and computation technology (Madhushree et al., 2020). Palero and Mutya (2022) assessed teachers' readiness for online distance learning. Based on the identified predictors, teachers were ready for online learning in the new normal. Although teachers faced challenges and struggles, they still acquired the competencies needed in the online teaching and learning environment.

Arora and Srinivasan (2020) investigated how many people are taking virtual classes and the advantages, drawbacks, and reasons for them not to be taken. The advantages were substantially less than the projected benefits among those who switched to virtual mode. They cited concerns with their networks, a lack of training, and a lack of awareness as the main obstacles they confront. The most common reason for those who did not accept virtual classrooms was a lack of awareness, followed by a lack of interest and questions about the effectiveness of virtual classes. Due to network concerns, virtual classrooms have been determined to have substantial disadvantages regarding attendance, personal touch, and interaction. A solution to the problems, disadvantages, and reasons why virtual classrooms are not being used.

In the Philippines, different online platforms were utilized for online learning. Reyes et al. (2021) investigated the level of e-learning readiness of Filipino higher education students during the pandemic. They found that Filipino students are ready in terms of computer/internet self-efficacy but not in terms of learner control. Gender significantly differentiates e-learning readiness under learner control and self-directed learning. Meanwhile, program classifications have significant differences in responses under computer/internet self-efficacy and online communication self-efficacy.

In distance learning, teaching mathematics can be challenging (Artigue, 2021; Oyebanji & Idiong, 2021). Friolo and Mutya (2022) found that mathematics teachers experienced challenges in teaching mathematics. Students' mathematics performance is far below the expected standard. Identified contributing factors were students' attitudes, teachers' workloads, digital infrastructure and gadgets, slow internet connections, lack of parents' support, and students' motivation. In addition, most mathematics professors and lecturers had mixed feelings about students' abilities and the teaching-learning environment. Improvements in teaching-learning settings, classroom instructions, teaching skills, student learning skills, teacher training programs, community attitudes, and accountability are suggested to address the problem (Cudillo et al., 2022; Mazana et al., 2020).

Subia et al. (2018) investigated the relationship between students' attitudes and performance in mathematics. Students' attitudes were significantly related to their performance in Mathematics. The higher their positive attitude, the higher their performance, and the lower their performance. The respondents feel that solving mathematical problems will improve their critical thinking skills and that if they are skilled at math, they will have a better chance of succeeding. When looking at the student's academic achievement in mathematics, the findings revealed a substantial positive high correlation between their study orientations and academic performance (Guinocor et al., 2020). In addition, Thanprasertsuk et al. (2021) found that most students had a positive impression of the new teaching approach utilized in the teaching process. Students appreciate its utility and that students who engage in this approach are more likely to perform well on assessments. Teaching methods that encourage more participatory learning may improve students' academic performance (İlçin et al., 2018).

Another study investigated the effects of various teaching strategies on student achievement using data from the OECD's so-called TALIS-PISA link. This new instrument connects data about teacher characteristics and practices collected in the PISA student academic performance and is measured in the TALIS (Teaching and Learning International Survey) survey (Programme for International Student Assessment). The findings indicated that traditional teaching methods positively impact students' mathematical proficiency (Cordero & Gil-Izquierdo, 2018). Many studies on the effects of teaching methods on student academic performance have been conducted, and the results have been significant (Okwuduba, 2018). Changing teaching strategies through interventions that include student-student and student-faculty interaction may provide an opportunity to improve course performance. Incorporating these interventions into teaching strategies improved students' performance in the course (Marwaha et al., 2021).

The studies and the literature reinforced the present study by providing the researcher's knowledge, information, and insights about online and virtual learning environments. Various authors' concepts and findings of their studies support the present study, particularly distance learning. However, the researchers also wanted to investigate the relationship between teaching strategies and students' mathematics performance in borderless classrooms.

Theoretical Background

This research study is anchored on e-learning theory and connectivism theory. E-learning theory demonstrated how educational technology could be used and designed to improve learning. This can maintain an interactive environment for teachers and students without having to be physically present for some nota-

ble instances. Also, teachers are becoming acquainted with specific strategies to deliver the lessons effectively and efficiently. Online learning can take the form of synchronous, real-time lectures and time-based outcome assessments or asynchronous, delayed-time activities such as pre-recorded video lectures and time-independent assessments (Oztok et al., 2013). Students who have resorted to online learning through google meet, zoom, and class – are prime examples of this theory. These students are learning virtually (Joaquin et al., 2020).

Connectivism theory implies interconnection. Teaching strategies employed in borderless classrooms should connect significantly to their students' performance. Connectivism promotes student retention by facilitating active connections, utilizing intelligent social networking, and encouraging student-generated curricula. As individuals co-create knowledge in a global, networked environment, connectivism allows for an optimistic, almost utopian view of the future of education (Darrow, 2009).

Methodology
Research Design
This study utilized descriptive research design to investigate the teaching strategies of mathematics college instructors in borderless classrooms and second-year mathematics students' performance. This method enables the interpretation of the theoretical meaning of the findings and hypothesis development for further studies and demonstrates a relationship between variables and cannot prove that changing one variable will change another (Carpenter & Huffman, 2012). It is ideal for gathering data quickly from natural settings. That helps you generalize your findings to real-life situations in an externally valid way (Bhandari, 2021).

Research Respondents
The study's respondents were mathematics instructors from a college in Cebu, Philippines. There were 15 mathematics instructors selected through a random sampling technique, 75% of the total population.

Research Instrument
A researcher-made survey questionnaire was used to gather the profile of the respondents and the teaching strategies of the respondents using a four-point Likert scale ranging from *"never"* to *"most of the time."* The instrument's content validity was conducted and authenticated by an expert in instrumentation. The evaluator's comments and suggestions were considered in the final draft, and the reliability was measured through Cronbach's Alpha, which is 0.96, interpreted as "excellent."

Data Gathering and Ethical Considerations
Consent approval from the President and the Research Director was secured before the conduct of the study. A letter to the course-incharge to ask for approval in getting the second-year mathematics students' grades in the first semester was also secured. Upon approval, the researchers sent an invitation, an informed consent form that indicates voluntary participation and roles of the respondents, and a provision to withdraw from the study at any time. A research outline with a copy of the participant's rights and confidentiality protection was also sent to the respondents via email and messenger. For confidentiality and anonymity, a code was assigned to each respondent. The data and information gathered by the researchers from their respondents were organized, tabulated, and analyzed.

Results and Discussion
Profile of the Respondents
A total of fifteen mathematics instructors participated in the study. Table 1 shows the descriptive statistics of the profile of the respondents. The demographic profile of the teachers consists of age, sex, civil status, highest educational attainment, relevant training courses, ICT training, and the number of years in teaching. Most respondents were male (80%), and their age groups mostly belonged between 31 and 35 years old (33%). Most were married (60%), and most were master's degree holders. Regarding the number of relevant training courses, teachers obtained an equal percentage (33.33%). As for ICT training, most mathematics instructors have attended one to three

training (53.33%). Lastly, regarding the number of years of teaching, most of the respondents had 1 to 5 and 6 to 10 years of teaching as mathematics instructors.

Table 1. Profile of Mathematics Instructors

	Profile	f	%
Sex	Male	12	80.00
	Female	3	20.00
Age	21 - 25 years old	2	13.33
	26 - 30 years old	3	20.00
	31 - 35 years old	5	33.33
	36 - 40 years old	3	20.00
	41 - 45 years old	1	6.67
	46 years old and above	1	6.67
Civil Status	Single	6	40.00
	Married	9	60.00
Highest Educational Attainment	With Masteral Units	3	20.00
	Master's degree holder	8	53.33
	With Doctoral Units	1	6.67
	Doctorate degree holder	3	20.00
Number of Relevant Training Courses	1-3 trainings	5	33.33
	4-6 trainings	5	33.33
	9 trainings and above	5	33.33
ICT Training	1-3 trainings	8	53.33
	4-6 trainings	4	26.67
	9 trainings and above	3	20.00
Number of Years in Teaching	1-5 years	5	33.33
	6-10 years	5	33.33
	11-15 years	1	6.67
	15 years and above	4	26.67

Extent of Use of Teaching Strategies in Borderless Classrooms

The extent of teaching strategies in borderless classrooms is shown in Table 2. Results revealed that mathematics instructors sometimes recorded their lectures. This variable had an aggregate mean of 2.73, interpreted as "some of the time," which means that they sometimes recorded their lectures and videos for at most 30 minutes each. Sometimes they provided a copy of recorded videos to the students. In terms of providing interactive activities, it was rated as "some of the time" with an aggregated mean of 2.96. An aggregate mean of 3.29 was revealed in terms of the writing of steps/examples on slides which is interpreted most of the time. Also, allowing the students to practice was observed most of the time, with an aggregate mean of 3.36. Setting objectives was

rated with an aggregate mean of 3.24, which is interpreted sometimes. Letting the students take control has garnered an aggregate mean of 3.29, which is interpreted most of the time.

The results showed that mathematics instructors allowed the students to practice. This was done most of the time. These include providing homework, letting the students do the other activities in the material, and asking someone to show their answers in class. This was undoubtedly for the drill. Essential feedback on computer-based homework can help novice students learn mathematics (Fyfe, 2016). According to one study, online homework is just as effective as traditional homework in student learning. Meanwhile, it was discovered that students who completed their homework outperformed students who did not (student-level). According to the researchers,

teachers should give students the option of doing online or traditional homework based on their preferences if they complete the homework (Liu & Wu, 2021).

Drilling is one of the most common devices and practices in our schools. It is a strenuous activity that allows for self-improvement. The fundamental facts and operations of mathematics must be memorized through excellent drills, but no mechanical cramming is permitted. Practice should be done with comprehension and a clear understanding of the objectives and goals (Kulbir, 2006). Writing the steps/examples on slides was used most of the time in terms of writing the steps/examples on slides, making them visibly clear to everyone in the class, and writing them legibly. Mathematics deals with formulas, theories, postulates, axioms, and laws. This is an aid to visual learners. This can help foster the ability of the students to demonstrate multicultural perspectives on mathematics that may help students develop a greater interest in mathematics (Brandt & Chernoff, 2015).

Letting the students take control of their learning was done most of the time. This was evident in the self-paced learning in today's educational setup. Educator Benjamin Bloom discovered that allowing students to master each course topic before moving on to the next improved their performance. The former has been shown to improve long-term learning outcomes and has recently been reintroduced as a popular approach in classrooms worldwide (Briggs, 2021). Before progressing to the next level, students must fully comprehend a lesson, regardless of the time or resources required (Chargois, 2013). In one study, the self-pacing group outperformed another group in which time was allocated automatically based on normative item difficulty. Only subjects who used a discrepancy-reduction strategy—that is, who allocated more study time to normatively difficult items – saw the benefit of self-pacing. Self-pacing has been shown to improve memory performance when appropriate allocation strategies are used (Tullis & Benjamin, 2011). Recording of lectures has been done some of the time in borderless classrooms. Lecture recording contributed to students' better understanding of the lecture (Odhabi & Nicks-McCaleb, 2011). They would have a great time and chance to get it viewed anytime and anywhere. Provided by the results, it is some valuable time.

Table 2. Descriptive Statistics on the Extent of Use of Teaching Strategies in Borderless Classrooms

Statements		Mean	SD	Interpretation
Recording of Lectures	I do record all my lectures in my class.	2.60	1.61	Some of the time
	I make my recorded videos at most 30 minutes each.	2.67	1.60	Some of the time
	I provide my students a copy of the video(s).	2.93	1.71	Some of the time
	Aggregate Mean	**2.73**	**1.64**	**Some of the time**
Providing Interactive Activities	I provide my students online quizzes to work on.	2.93	1.71	Some of the time
	I initiate online games to lit the atmosphere.	2.93	1.71	Some of the time
	I employ doing the oral recitation in my class.	3.00	1.73	Some of the time
	Aggregate Mean	**2.96**	**1.71**	**Some of the time**
Writing the Steps and Examples on Slides	I write the steps or examples on my slides.	3.40	1.84	Most of the time
	I make sure it is visibly clear to everyone in my class.	3.33	1.83	Most of the time
	I write it legibly.	3.13	1.77	Some of the time
	Aggregate Mean	**3.29**	**1.81**	**Most of the time**

Statements		Mean	SD	Interpretation
Allowing Students to Practice	I provide homework for my students to practice.	3.47	1.86	Most of the time
	I let them do the other exercises in the material.	3.27	1.81	Most of the time
	I ask someone to show their answers in my class.	3.33	1.83	Most of the time
	Aggregate Mean	**3.36**	**1.83**	**Most of the time**
Setting Objectives	I start my class by setting objectives of the lesson.	3.33	1.83	Most of the time
	I want my students to know what is expected from them.	3.13	1.77	Some of the time
	I want to check if we have achieved it at my class.	3.27	1.81	Most of the time
	Aggregate Mean	**3.24**	**1.80**	**Some of the time**
Letting Students to Take Control	I let my students to ask help from their peers when in doubt.	3.27	1.81	Most of the time
	I want my students to take control of their own learning.	3.13	1.77	Some of the time
	I want them to prosper and be great learners.	3.47	1.86	Most of the time
	Aggregate Mean	**3.29**	**1.81**	**Most of the time**

Effect of Teaching Strategies on the Students' Performance

The effect of teaching strategies on the student's performance is shown in Table 3. The first semester average academic grades of the second-year mathematics students were all interpreted as "*very good*". Trigonometry has a mean of 2.2. Plane and Solid Geometry have a mean of 1.9. Logic and Set Theory have a mean of 1.7. Elementary Statistics and Probability has a mean of 1.5.

The results implied that the borderless classrooms' teaching strategies affect the second-year mathematics students' performances in class. When looking at the student's academic achievement in terms of their Graded Point Average (GPA) in Mathematics subjects, the findings revealed a substantial positive high correlation between their study orientations and their academic performance (Guinocor et al., 2020). The students have managed to get excellent grades in all those subjects; it can be understood that the teaching strategies used in the borderless classrooms have affected the students to a great extent. As noticed, the students performed very well in most of their course subjects in mathematics. With regards to trigonometry, they could only perform well at it.

Trigonometry is a mathematical concept that students regard as complex, and abstract compared to other branches of mathematics. Trigonometry is frequently introduced in year 8, with most textbooks typically beginning with naming sides of right-angled triangles. The study discovered that students make mistakes, have misconceptions, and encounter obstacles in trigonometry lessons. The most common errors made by students in questions were chosen. Several problematic areas have been identified, including incorrect equation use, order of operations, and the value and location of sin, cosine, misinterpreted data, language, logically invalid inference, distorted definition, and technical mechanical errors (Gur, 2009). In addition, Thanprasertsuk et al. (2021) found that most students had a positive impression of the teaching strategy at the end of the course, which was significantly higher than 50.7 percent at the start of the course. The findings suggested that after experiencing this new teaching approach, students appreciated its utility and that students who engaged in this approach were more likely to perform well on

assessments. Teaching methods that encourage more participatory learning may improve students' academic performance (İlçin et al., 2018).

Table 3. First Semester Average Academic Grades

Subject Codes and Descriptive Titles	Mean	Indicator
Math 102 (Trigonometry)	2.2	Good
Math 103 (Plane and Solid Geometry)	1.9	Very Good
Math 104 (Logic and Set Theory)	1.7	Very Good
Math 105 (Elementary Statistics and Probability)	1.5	Very Good
Aggregate Mean	**1.8**	**Very Good**

Legend: 1.0-1.3 (Excellent); 1.4-1.9 (Very Good); 2.0-2.5 (Good); 2.6-3.0 (Fair); 5.0 (Failed)

Teaching Strategies in the Borderless Classrooms and the Students' Performance in Mathematics

The significant relationship between teaching strategies in borderless classrooms and second-year mathematics students' performance was revealed. The r statistic is 0.49, and the p-value is 0.04, which is less than the significant value of 0.05.

There is a significant positive relationship between the teaching strategies in the borderless classrooms and the student's performance in mathematics r (13) = .49, p< .04. That means to say that the teaching strategies used in the borderless classrooms are found to be significantly affecting the student's performance that is made visible through their semester grades. Many studies on the effects of teaching methods on student academic performance have been conducted, and the results have been significant (Okwuduba, 2018). Teaching styles greatly influence students' academic achievement (Nijiru et al., 2020). The more the teachers use it, the better the students' performance. Cordero and Gil-Izquierdo (2018) investigated the effects of various teaching strategies on student achievement. The findings indicate that teaching method positively impact students' mathematical proficiency. In addition, changing teaching strategies through interventions that include student-student and student-faculty interaction may provide an opportunity to improve course performance. Incorporating these interventions into teaching strategies improved students' performance in the course (Marwaha et al., 2021).

Table 4. Significant Relationship

Variables	Significant Value	r statistic	p-value	Interpretation
Teaching Strategies and Students' Performance	0.05	0.49	0.04	Significant

Conclusion

Teachers have different perceptions regarding the different strategies in the borderless classroom. The teaching strategy used by this teacher may apply to more than just the other teacher. The mathematics instructors used strategies such as writing the steps and examples on slides, allowing students to practice and letting students take control all the time in their class. On the other hand, teaching strategies such as recording lectures, providing interactive activities, and setting objectives were perceived as sometimes practiced during class discussions. Overall, the teachers utilized different strategies and effectively delivered the lesson. These can be seen in the student's performance in mathematics subject. Having very good remarks in the students' overall grades indicates that amidst the pandemic crisis, teaching strategies employed in the borderless classrooms significantly affect the students. The remarks in their grades proved that the teaching strategies matter whether in the traditional or virtual education setup. Teaching strategies have a significant positive relationship with student performance through

academic achievement. This information provides an essential insight that teaching strategies successfully influenced students' performance in face-to-face classes or virtual education.

Recommendation

Much has been said about the importance of teaching strategies in borderless classrooms. Their roles are important in keeping learning going amid the pandemic. The researchers proposed S.I.A.A.T or Strategic Intervention Applied in Asynchronous Teaching. This program will ensure that students will continue to receive asynchronous learning in borderless classrooms. The teaching strategies will be student-focused where it will include interactive discussions and gamification. It will also equip the teachers on the pedagogy of technology integration.

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