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Writing Activities as Intervention for Improving Academic Achievement in Mathematics

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Abstract: Much research in Mathematics instruction has focused on collaborative learning and differentiated instruction. However, very little research in the Philippines focused on utilizing writing activities as an instructional intervention. Even in Mathematics, a subject grounded in computations, this can be beneficial. By explaining how a problem is solved, or why a solution is erroneous, students will learn how the concepts may be applied in a deeper sense. Given the pandemic's limits and the Philippines' low-performance ratings in international assessments, there is a pressing need to develop innovations to continue learning. Hence, this study investigated whether writing activities are effective in improving academic achievement in mathematics classrooms. Using an explanatory sequential mixed methods design, the study involved selected Grade 8 students in a public school in Pasig City. The results of the quantitative data showed a significant difference in the pre-test and post-test scores of the experimental group as compared to the control. This was supported by the qualitative data which revealed that writing activities help understand the topics, remember concepts, and serve as a reviewer before an assessment. Overall, the study suggests that writing activities as an intervention in mathematics are effective in improving the student's academic achievement.

Keywords: *Academic achievement, intervention, mathematics, writing activities.*

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Introduction

Mathematics is one of the subjects in school that is truly essential to learning. It is not just about adding or subtracting numbers or finding values of x and y; it is much more than that. Even the famous Galileo Galilee has stated, "Mathematics is the language in which God has written the universe." Likewise, according to Minarni (2017), in the process of investigations, mathematics plays a vital role.

Mathematics must be learned with great cognitive and metacognitive effort because related skills do not develop naturally (Katz, 2015). Although Semeraro et al. (2020) found that the total intellectual capacity is the leading impact in high mathematical achievement over mathematical ability, Genc and Erbas (2019) clarified that this does not rule out the possibility of developing mathematical skills of those who lack inherent mathematical ability. It means that it may be achieved but longer, through hard work and persistence. Thus, much like any other subject, it takes determination and practice. Since mathematics entails learning numerous cognitive thinking skills and abilities, students sometimes have the connotation of the subject is too difficult (Li & Schoenfeld, 2019; Nfon, 2018).

In the study of Jaudinez (2019), he stated that low performance of students in mathematics may be attributed to their lack of mastery in the fundamental skills. More so, Etcuban and Pantinople (2018) observed students' low academic achievement in the subject and identified that students have higher achievement on rote learning and below par on those that require understanding and problem-solving skills. This was further supported by the study of Özyıldırım-Gümüş and Şahiner (2017) which stated that the education system gives more importance to solving problems related to a definition rather than using this definition to make a concept clear. Thus, persons in authority must identify the problems and try to arrive at a solution to address the concerns.

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Adding to these challenges, not just to the mathematics subject but to the entire education system, is the occurrence of the pandemic. The schools, especially in the past two years, are evidently different. The pandemic has changed the course of the environment, greatly affecting the education system. Most schools were mandated to resort to a different learning delivery modality, preferably online learning, because of the pandemic. Due to this shift in the mode of instruction, teachers have a responsibility to look for innovations and creative strategies on how to make the subject more enjoyable to the students, and more importantly, improve their academic achievement in the subject. One of the emerging ways to do this is through writing activities.

Dündar (2016) and Çerçi (2016) agree that one of the best tools for effective communication between teachers and students is utilizing writing activities. Researchers considered the act of writing to be inevitably engaging to students, making writing like a magic formula to increase the development of the learning process (Teuscher et al., 2015). This approach is also being used in mathematics subject.

Countryman (1997, as cited in Dündar, 2016) stated that mathematics is one way to understand the world, and to understand mathematics, one of the ways is writing. B. Braun (2014) described that writing allows the students to articulate their feelings, make connections on their understanding, give their perspective on other works, and create new outcomes based on their knowledge. Respectively, these are personal writing, expository writing, critical writing, and creative writing. These writing activities may come in journals, learning logs, and formal papers, as stated by Teuscher et al. (2015), and are used in the different subjects in school. However, Bossé and Faulconer (2008, as cited in Powell et al., 2017) specified what mathematics writing is about and they described it as any writing about mathematics like writing about certain mathematicians, and writing in mathematics, such as explaining ideas learned in mathematics class.

Having to use writing activities in the subject helps to create a better connection between the students and the lessons taught by the teacher. Moreover, writing activities in mathematics employ students' thinking processes for them to discover realities that are found beyond the borders of the classrooms (Connelly, 2005, as cited in Dündar, 2016). By writing how they solve a problem, or why they find a solution erroneous, the students will be able to understand how the concepts can be used more comprehensively.

However, students in mathematics classrooms may not be quite familiar with the use of writing activities. According to Burns (2004, as cited in Dündar, 2016), there are four categories for writing assignments, namely, journal logs, math problem solving, explanation of mathematical ideas, and writing about processes. In this study, the intervention focuses on two categories: explanation of mathematical ideas and writing on the processes. Most learners see the process of learning in mathematics as simply memorizing step-by-step procedures to answer exercises from the teacher (Yunus et al., 2016, as cited in Suhaimi et al., 2016). Through writing activities, guided by the teacher, students can create meaningful connections with the concepts they have learned in class (Guce, 2017), which may lead the learners to improve their academic achievement.

In general, the term "academic achievement" relates to the skills and learning competencies in different areas such as communication, mathematics, and science, which enable a learner to succeed in school and society (Genesee et al., 2006). In this study, academic achievement pertains to the significant improvement of the students' pre-test and post-test scores in the mathematics subject.

This study will therefore allow the researchers to recognize if writing activities are effective to use as an intervention in mathematics classrooms by determining if there will be an improvement in the student's academic achievement upon its implementation. Specifically, the study aims to answer the following questions:

RQ1. Is there a significant difference in the pre-test scores between the control and experimental group?

RQ2. Is there a significant difference between the pre-test and post-test scores of control group?

RQ3. Is there a significant difference between the pre-test and post-test scores of experimental group?

RQ4. Is there a significant difference in the post-test scores between the control and experimental group?

RQ5. What are the insights of the students about the use of writing activities in learning mathematics?

Methodology

Research Design

Explanatory sequential mixed methods design was used in this study. With this, the researcher collects quantitative data, then gathers qualitative data that supports the quantitative data (Creswell & Clark, 2017). In the quantitative phase, the data was gathered through a quasi-experimental design, pre-post with a nonequivalent control group, and analyzed through independent and dependent t-tests using SPSS software. In the qualitative data, journal entries were collected and analyzed using thematic analysis. Both data were interpreted together to strengthen the results of the study.

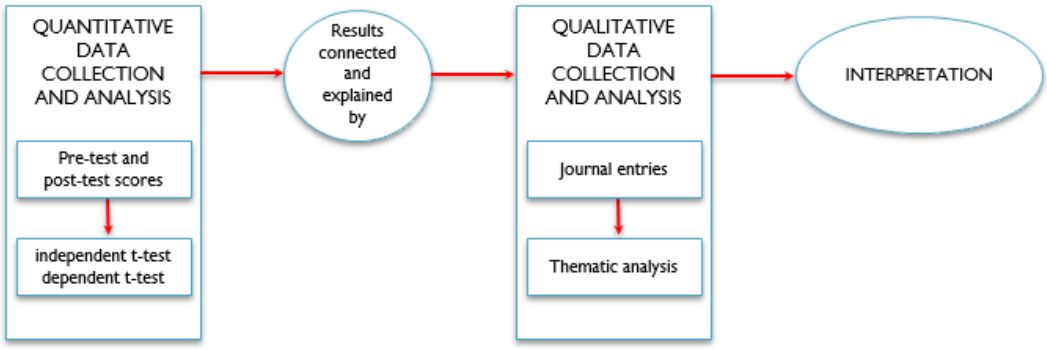

Figure 1. Explanatory Sequential Mixed Methods Design, as Used on the Study

Sample and Data Collection

The selection of respondents was done through purposive sampling, which involves two sections from Grade 8. Choosing these participants is in line with the involvement of the Philippines in PISA, assessing students in the eighth grade. The number of participants in this study is 80 Grade 8 students, with 40 students from each section from one public school in Pasig City, Philippines. Students from Section A are part of the control group, while students from Section B are part of the experimental group.

This study was conducted for 6 weeks. Because of the limitations of the pandemic, the University of Santo Tomas Graduate School Review Ethics Committee (USTGS-REC) was unavailable. To pursue the ethics review, the study was endorsed to the University of Santo Tomas Faculty of Pharmacy Research Ethics Committee for ethical clearance. Upon its approval, the researcher sent a letter to the school principal of the study site for permission to conduct a study. After this, the assent and informed consent forms were sent and collected to the students and parents via Google Forms.

Both sections answered the pre-test, a 30-item assessment on the topics of Conditional Statements and Writing Proofs. This served as a diagnosis of the student's level of knowledge of the modules to be discussed, thus, the scores are recorded but not graded.

Two self-learning modules were discussed weekly with the students via the Zoom platform. However, during the second week, online classes were suspended due to the rise in COVID-19 cases. Hence, this week, classes were asynchronous.

One output per module is prescribed by the school. Section A, the control group, was assigned to answer one activity from their self-learning modules. Activities in the self-learning modules are mostly objective-type questions. Sample responses from the students in Section A are shown below:

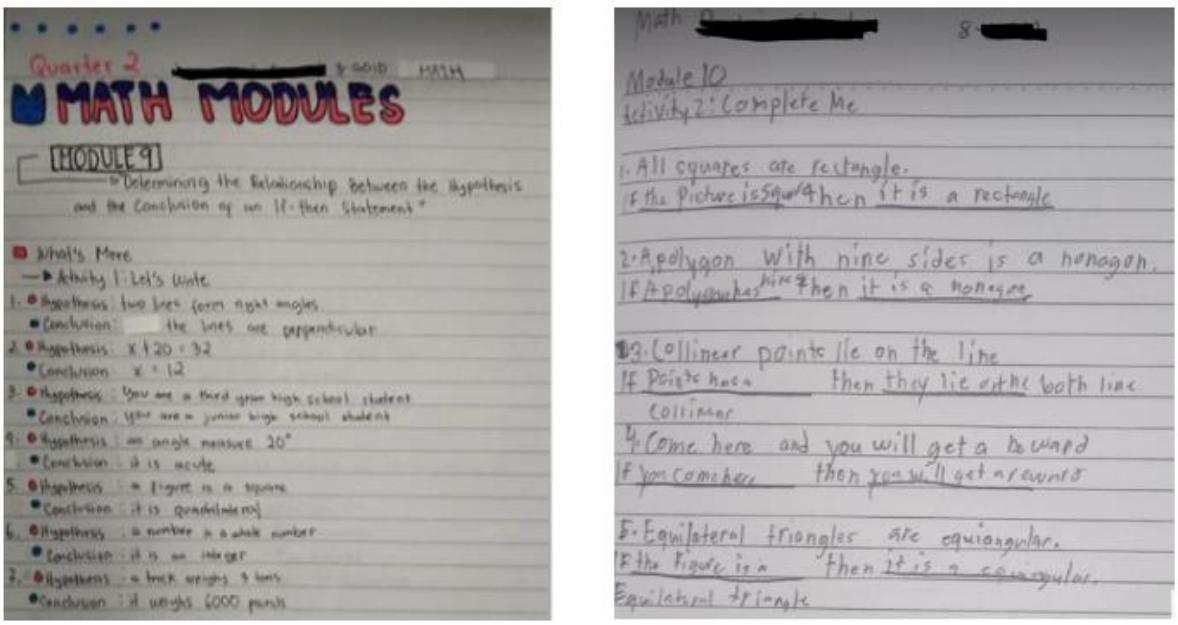

Figure 2. Sample Module Output Responses, Section A (Control Group)

For Section B, the experimental group, they were tasked to answer the intervention tool. Instead of answering objective-type activities, they will be answering the writing activity forms that allow them to write the big concepts, formulas, and

processes that they have learned. At the end of each form, the students will be given an erroneous solution or situation, or problem to solve and they were tasked to explain their answers. Sample responses are shown below:

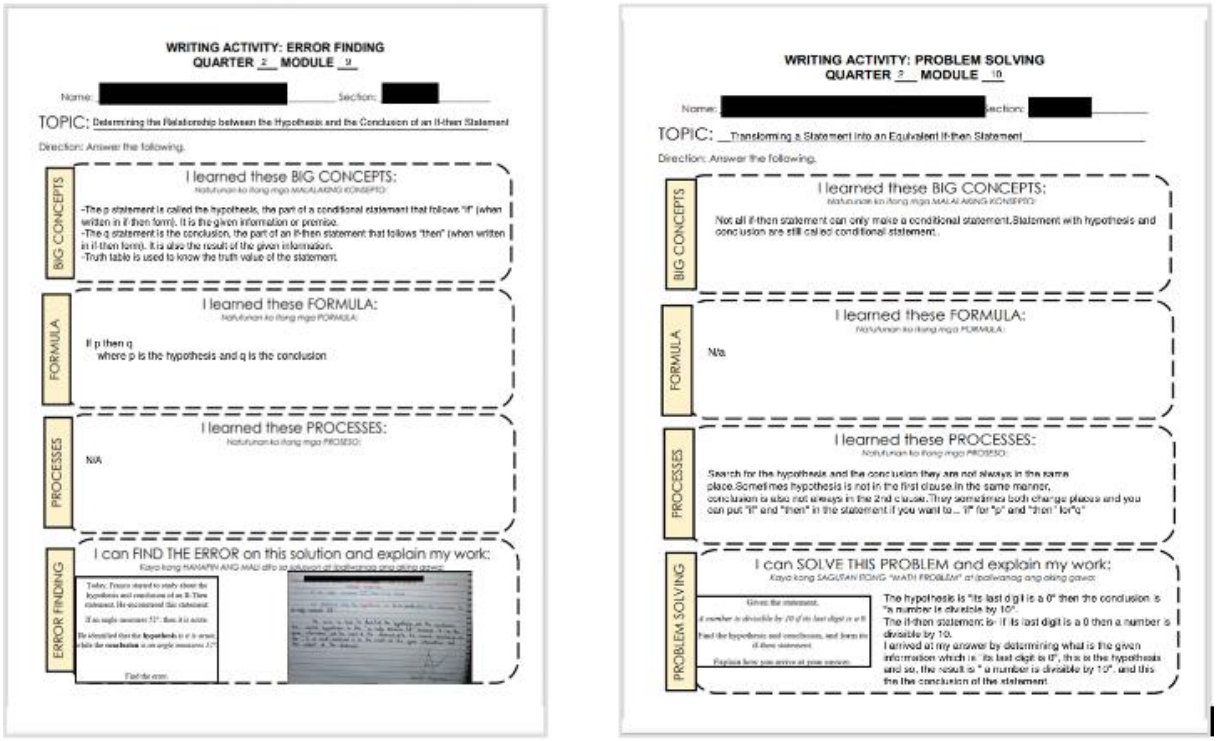

Figure 3. Sample Module Output Responses, Section B (Experimental Group)

Aside from the module outputs, the learning experiences of the students from both sections are similar. After the discussion of the topics, both sections answered the post-test. This is a 30-item assessment, with questions parallel to the pre-test. In this, the scores of the students are both recorded and graded.

Afterward, the journal entries of the students were gathered and completed using the Journal Writing Form. Upon completion, the researcher proceeded with the analysis of data for the study.

Data Analysis

To determine whether there is a statistically significant difference between the mean scores of the pre-test of the control and experimental group, and the post-test of both groups, independent t-test was used. Similarly, to determine the significant difference of the pre-test and post-test scores of the control group, and the pre-test and post-test scores of the experimental group, dependent t-test was used. Both were analyzed through the SPSS Software version 25. Upon analyzing the pre-test scores of both sections using independent t-test, the results revealed that there is no significant difference in the pre-test performances of the two groups, implying that they are assumed to be equal.

For the qualitative data, the researcher used the answers of the participants in the Journal Writing Form. The journal entries of the students strengthened the quantitative results using thematic analysis. This is an approach to analyze qualitative data, such as journals, that give focus on identifying themes and patterns on the data (V. Braun & Clarke, 2019). The researcher began with initial coding, which reveal 10 broad codes. After accomplishing this, the researcher started to make meaning of the code by revisiting them and categorize into groups. All these categories were scrutinized to form the themes. An inter-coder helped establish the reliability of analyzing the qualitative data.

Findings/Results

Quantitative Phase

To answer RQ1 and compare the pre-test scores of Section A and Section B, an independent t-test (independent samples test) was conducted. This was used since two groups independent of each other are being compared.

Table 1. Pre-Test Control and Experimental Group Statistics

	Group	N	Mean	Std. deviation	Std. error mean
Pre-test	Control	40	9.63	4.289	.678
	Experimental	40	8.88	3.917	.619

Table 2. Pre-Test Control and Experimental Independent Samples Test

		Levene's test for equality of variances		t-test for equality of means						
									95% CI	
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
Pre-test	Equal variances assumed	1.283	.261	.817	78	.417	.750	.918	-1.078	2.578
	Equal variances not assumed			.817	77.367	.417	.750	.918	-1.079	2.579

The results states that the mean difference = 0.75 between the pre-test of Section A (M = 9.63, SD = 4.29) and pre-test of Section B (M = 8.88, SD = 3.92) is not significantly different from each other (t (78) = 0.82, p = 0.417). The 95% confidence interval of the difference is between - 1.08 and 2.58. To know how large the difference between the groups is, the effect size was computed using Cohen's d formula. It resulted d = 0.18 standard deviation between the groups, which is considered to be a small effect.

To answer RQ2, the pre-test and post-test scores of Section A were analyzed using a dependent t-test (paired samples test). A dependent t-test was utilized since this is used to compare two groups of scores and their means, in which the participants of two groups in comparison are related to each other.

Table 3. Paired Samples Statistics

		Mean	N	Std. deviation	Std. error mean
Control	Pre-test	9.6250	40	4.28885	.67813
	Post-test	16.5250	40	4.35588	.68873
Experimental	Pre-test	8.8750	40	3.91701	.61933
	Post-test	18.7750	40	4.15401	.65681

Table 4. Paired Samples Correlations

		N	Correlation	Sig.
Control	Pre-test and post-test	40	.711	.000
Experimental	Pre-test and post-test	40	.558	.000

Table 5. Paired Samples Test

		Paired differences					t	df	Sig. (2-tailed)
				Std.	95% CI				
		Mean	Std. Deviation	Error Mean	Lower	Upper			
Control	Pre-test – post-test	-6.90	3.28790	.51986	-7.95152	-5.84848	-13.273	39	.000
Experimental	Pre-test – post-test	-9.90	3.80148	.60107	-11.11577	8.68423	-16.471	39	.000

Scores on pre-test of the control group (M = 9.63, SD = 4.29) and post-test (M = 16.52, SD = 4.36) has a mean difference = -6.90. This is considered to be a significant difference (t (39) = -13.27, p < 0.001). The 95% confidence interval of the difference is between -7.95 and -5.84. The effect size d = 2.09 standard deviation between the two conditions is considered as a large effect.

The pre-test and post-test scores of Section B were analyzed using a dependent t-test (paired samples test), as seen in Table 5, answers RQ3.

The pre-test scores of the experimental group (M = 8.88, SD = 3.92) and their post-test (M = 18.78, SD = 4.15) resulted in a mean difference = 9.90. This is also considered to be a significant difference (t (39) = -16.47, p < 0.001). The 95%

confidence interval of the difference is between - 11.12 and -8.68. The effect size *d* = 2.61 standard deviation between the two conditions is also considered to be a large effect.

To answer RQ4 and determine if writing activities is effective in improving the academic achievement of the students, an independent samples t-test was used to compare the post-test scores for Section A and Section B.

Table 6. Post-Test Control and Experimental Group Statistics

	Group	N	Mean	Std. deviation	Std. error mean
Post-test	Control	40	16.53	4.356	.689
	Experimental	40	18.78	4.154	.657

Table 7. Post-Test Control and Experimental Independent Samples Test

		Levene's test for equality of variances		t-test for equality of means						
									95% CI	
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
Post-test	Equal variances assumed	.000	.990	-2.364	78	.021	-2.250	.952	-4.145	-.355
	Equal variances not assumed			-2.364	77.825	.021	-2.250	.952	-4.145	-.355

The scores on the post-test of control group (*M* = 16.53, *SD* = 18.78) and post-test of experimental group (*M* = 18.78, *SD* = 4.15) has a mean difference of 2.25. It is considered to be a significant difference (*t* (78) = -2.364, *p* = 0.021). The 95% confidence interval of the difference is -4.15 and -.35. The effect size resulted *d* = 0.53 standard deviation between the two groups, which is considered as a medium effect.

Qualitative Phase

Journal entries of 12 participants were analyzed through thematic analysis. To answer RQ5, three themes were revealed, namely: (1) writing activities facilitate a better understanding of mathematics lessons, (2) use of supplementary activities make writing activities more effective, and (3) hindrances affect the implementation of writing activities.

For the first theme, the results revealed that utilization of writing activities helped the students learn the topics with ease. This intervention allowed the students to remember and retain information better.

> Respondent 3: The writing activities helped me to remember the different words in the topic.
>
> Respondent 4: The writing activities helped me understand better because I can remember the big concepts more easily.
>
> Respondent 5: The topics for Modules 11 and 12 have many definitions, but it is easy. Our output (writing activities) summarized the definitions that we had to learn.

Even in the topics claimed by the participants as difficult, writing activities helped them grasp the material better by allowing them to recall the process. More so, the intervention aided the students before an assessment since they used these as a reviewer. Reviewing their answers in the writing activities allowed them to go over how they answered a problem using their own words.

> Respondent 3: I read the questions carefully. I reviewed before the test by rereading my module output.
>
> Respondent 4: …In the last part (of the writing activity), it helped me recall how I answered the problem because of my explanation.

For the second theme, the results found that writing activities alone may not be effective in improving the students' academic achievement. Rather, this intervention should be accompanied by other instructional strategies in the classroom. From the journal entries, two main strategies were found to make the intervention more effective. First, class discussions helped the intervention to be more effective because the teacher communicated the content.

> Respondent 1: Our teacher explained it very well that made me understand the topics better, so I rated it 5.

> Respondent 2: The teacher's presentation and her explanations made me understand the lessons or the topic better.
>
> Respondent 7: I fully understood the topics because of the clear examples my adviser gave me.

More so, class discussions in synchronous classes involved teacher-student interaction (Kohnke & Moorhouse, 2022; Lim, 2017), where the students not only listened, but participated actively. This improved the students' level of understanding (Khan & Rafi, 2020). Conversely, writing activities helped class discussions to be more engaging. Aside from class discussions, the video lessons also helped in making the intervention effective.

> Respondent 11: It helps me when I recite in class and listen.
>
> Respondent 8: Reciting when we are discussing the questions helped me learn.
>
> Respondent 7: The video lesson that my adviser sent us helped me understand the topics better
>
> Respondent 5: I reviewed using the video lessons and writing activities.

For the last theme, hindrances were found in utilizing writing activities, and having the study conducted in an online learning setting. The most prominent challenge in online learning is having a slow and unstable internet connection (Mina et al., 2020), since class discussions and learning resources are found and conducted online and in need of a stable and reliable internet connection (Fabito et al., 2020). Students with unreliable internet connections show struggles in learning (Adnan & Anwar, 2020), making this a crucial concern in this learning modality as they may miss out on the complete learning experience (Dhawan, 2020). Having an unstable or slow internet connection was claimed by the students as challenge in the use of writing activities.

> Respondent 6: I was late for 5 minutes because of the slow internet.
>
> Respondent 11: The topic is week is easy but I rate it with 4 (out of 5) because of the internet. This week the internet is not stable.

Students also identified that having the asynchronous classes hindered them from fully learning the lessons. Asynchronous classes mean meeting only through Facebook Messenger and not through the Zoom platform. It hinders the students from learning when there is limited interaction between the teacher and the students (Adnan & Anwar, 2020). Disengagement is felt more in asynchronous classes (Iyer & Chapman, 2021).

> Respondent 1: Not having an online class and recitation to have a well-explained lesson hindered me from learning the topics better.
>
> Respondent 2. What hindered me from learning is that there is no teacher to explain the lesson. Since it is an asynchronous week, it is not explained via Zoom.

Both these challenges affect the utilization of writing activities. Lack of internet connection and classes done asynchronously limit the teacher-student interaction. These challenges affect some students who take notes or answer the writing activities during class discussions.

> Respondent 4: I found the lessons this week quite easy. While the teacher is explaining, I am answering the output (writing activity).

As previously stated, class discussion combined with the intervention can make writing activities more effective. Hence, these abovementioned challenges may impede learning and lessen the effectiveness of the writing activities for these types of students.

Discussion

The study utilized an explanatory sequential mixed methods design to determine whether the use of writing activities in the mathematics classroom can improve students' academic achievement. The researchers obtained and examined quantitative data first, then qualitative data to back up the quantitative data, as explained below:

Upon analyzing the pre-test scores of both sections using independent t-test, the results revealed that there is no significant difference in the pre-test performances of the two groups, implying that they are assumed to be equal. From this, the writing activities intervention was given to Section B, the experimental group, as a module output. After which, both sections completed the post-test. The scores on this assessment were analyzed using an independent t-test, which revealed a significant difference between the two groups' post-test results. This suggests that the intervention of employing writing activities to improve students' academic achievement in mathematics is effective. This is in contrast with the study of Markert (2019) which revealed that in a mathematics classroom, there is no significant difference between writing to learn activities and academic achievement.

Section A's pre-test and post-test scores, as well as Section B's pre-test and post-test scores both showed that the scores were significantly different. This suggests that from the pre-test to the post-test, both sections greatly improved their performance. Yet, when the mean difference between the two groups was calculated, Section B has a higher mean

difference than Section A. These findings reveal that, while both sections have improved, the intervention of using writing activities as the students' output is more effective in improving academic achievement than traditional activities done in a mathematics classroom. These results were reinforced by the second theme of the qualitative data. As previously mentioned, aside from the module outputs, Section A and Section B had similar learning experiences. Theme 2 recognized that writing activities alone may not be useful in increasing students' academic achievement (Atasoy & Küçük, 2020; Powell et al., 2017). Rather, other classroom instructional strategies should be used in conjunction with this intervention, such as class discussions and video lessons. As these two strategies were used in both classrooms, improvements in the students' academic achievement were expected. However, Section B, the group which received the intervention, had a greater increase in their pre-test and post-test performance than Section A as revealed in the quantitative data. Hence, writing activities became a fundamental factor in the improvement of the students' academic achievement in mathematics.

The post-test scores of Section A and Section B both revealed a significant difference. This suggests that the intervention of employing writing activities to improve students' academic achievement in mathematics is effective. This was strengthened by the findings of the first theme of the qualitative data. Theme 1 supported the effectiveness of the intervention and demonstrated that the use of writing activities helped students learn the topics more easily (Thropp, 2017). This intervention improved the students' ability to remember and retain knowledge. More so, writing activities are especially beneficial to students before an assessment since they utilize it as a reviewer, where they can go over how they answered a problem in their own words. Since this intervention posed various ways of how writing activities aid in learning mathematics, it further showed its effectiveness. However, the identified hindrances from Theme 3 should be addressed to have a better utilization of the intervention.

Overall, the findings of this study showed not only the intervention being effective in improving students' academic achievement in mathematics. It also displayed how it positively contributed to the students' learning experiences in mathematics classroom. The use of writing activities in this study allowed the students to create meaningful connections on the topics discussed (Guce, 2017; Kandil, 2021; Sailin & Mahmor, 2016), which ultimately led to the significant increase in their academic achievement (Hughes & Lee, 2020; Kaur & Prendergast, 2022).

Conclusion

The findings of the study have led the researchers to conclude that the writing activities intervention was effective in improving the academic achievement of the participants of the study. This intervention is advantageous for the students to have another strategy to easily learn mathematics. This may be used to lessen the difficulties experienced by the students as it promotes a better engagement with the subject. Moreover, students can use these writing activities to gain better assessment results on the subject.

Furthermore, mathematics teachers are presented with an additional instructional strategy to use in mathematics classrooms that is effective in the online learning modality. This intervention can effectively support the existing strategies of the teacher and encourage a strong teacher-student interaction. Additionally, curriculum developers may adapt these activities and integrate them into the learning materials of the students. However, despite the positive outcome of this study, its limitations, such as the learning modality and the number of participants, should be considered.

Recommendations

The study investigated the effectiveness of writing activities as an intervention for improving academic achievement in mathematics. Based on the findings of the study, mathematics teachers should explore how to further utilize this simple writing activity to improve mathematics teaching and learning. The use of the intervention should not be limited in the way it was used in the study, as writing activities may be utilized before, during, or after class discussions. A seminar-workshop for mathematics teachers may be held for those who choose to provide and apply writing activities in class discussions. Likewise, curriculum and instructional developers, as well as textbook writers, may use the findings of the study to incorporate the use of writing activities in creating learning materials for the students.

For future studies, researchers can conduct the study outside the online learning modality. For the quantitative data, studies may use true experimental design and apply the intervention to a larger population to get a broader analysis of its effects. Also, additional qualitative approaches, such as interviews and observation of both students and teachers may be utilized, to get a deeper understanding of the data. More so, similar studies can be done to explore how these writing activities affect other student-related factors such as metacognition, motivation, and attitude in learning mathematics. Lastly, since the current study only focused on the topics of Conditional Statements and Writing Proofs, future studies on the use of writing activities may be extended to other topics in mathematics, across all levels.

Limitations

The findings of the study cannot be generalized on a large scale due to the limited number of participants. However, these findings can be used for further studies related to the topic. Moreover, the study was done in the online learning modality and focused on the topics of Conditional Statements and Writing Proof in mathematics. For future studies, the researchers

recommend utilizing the intervention in the face-to-face or blended learning modality and extending it to other topics in mathematics across all levels.

Ethics Statements

The University of Santo Tomas Faculty of Pharmacy Research Ethics Committee, as endorsed by the University of Santo Tomas Graduate School Review Ethics Committee, approved to conduct this study after all the requirements were complied with. The researchers asked permission to conduct the study in the participating school by sending a letter of request to the school principal. Only upon their approval did the researchers begin with any data-gathering procedure.

The potential participants were asked to take part in the research study. Before they decided to participate, assent forms were given for them to understand why the research was being done and what it would entail, as it included the purpose of the study, research procedures, risks, benefits, and compensation. This also stated the confidentiality and voluntary aspects of being a participant in the study. Since the potential participants are minors, informed consent letters were sent to their parents or legal guardian. Both the assent and informed consent forms must be signed before a child is considered a participant in the study. However, participants were still free to withdraw from the study. In this case, all collected data would be destroyed as soon as they withdraw from the study.

Assigned numbers for participants were used on all research notes and documents. Additionally, the participants were assured of confidentiality and anonymity of all the data gathered in the study, except in cases where the researcher is legally obligated to report specific incidents.

Authorship Contribution Statement

Raquid: Conceptualization, design, analysis, and writing. Litao: Analysis, editing, reviewing, and supervision.

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