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From Graphs to Paragraphs: An Analysis of the Use of Writing in Teaching and Learning Mathematics

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ABSTRACT
Communication and independent learning skills are becoming more and more crucial in this era of machine learning. This forces our teachers to experiment with new teaching techniques in order to meet the demands of the modern world. In mathematics education for instance, the use of various writing activities, which have traditionally been seen as insignificant in Mathematics teaching and learning, has gained attention education due to its potential to foster critical thinking and provide students a sense of purpose in their study. By giving students the opportunity to meaningfully explore concepts, writing in math instruction is one method that helps students make the connection between mathematics and the real world. However, it is not well known how much writing is used as a teaching tool in math classes.
This study investigated the extent of use of writing activities in Mathematics teaching and learning of 73 high school math teachers in Cagayan. The study found out that writing is not frequently utilized as a teaching technique in math classes, and the majority of the teachers surveyed said they used writing exercises in their math classes less than once per week. Additionally, it was discovered by the survey that teachers who had received training in using writing as a teaching tool were more likely to do so in their math classes. The majority of teachers, however, claimed that they had not been given any training on how to incorporate writing into the teaching of mathematics..

Keywords: Writing in Mathematics, Mathematics Teaching, Journal Writing in Mathematics, Impromptu/Writing prompts in Math

INTRODUCTION

According to a famous statement by Galileo Galilei, mathematics is the language in which the world is written. It suggests that we need to learn the language and symbols of mathematics to understand the universe. Mathematics uses geometric shapes to convey complex ideas that cannot be fully understood without this language. Without mathematical language and symbols, comprehending the universe would be difficult.
Mathematics is a language because it uses precise terms and symbols to express complex ideas and processes. To communicate and think like mathematicians, students must learn its unique vocabulary and register. Despite linguistic differences, the structure of mathematical language remains consistent and unchanging. Mathematicians use both mathematical notation and written language, including sentences and paragraphs, to express increasingly complex and sophisticated concepts.
Writing is an essential tool in mathematics education. Writing exercises encourage students to explore ideas from different perspectives, promoting critical thinking skills and active engagement in the teaching-learning process. Writing facilitates communication between students and instructors, and instructors use written work to assess understanding and guide educational decisions. Writing activities can make mathematical concepts more engaging, encouraging creativity, and making the learning experience more meaningful.
Engaging in writing activities significantly improves a student's learning experience in mathematics (Mamauag, 2023). Writing is an effective tool for enhancing a student's knowledge and comprehension of the mathematical concepts they encounter. The process of writing facilitates learning and retention of concepts explored in math class. Writing activities provide an avenue for students to explore mathematical ideas in new and innovative ways, fostering the development of critical thinking skills.

Writing as a Tool in Mathematics Instruction

Writing is an essential skill in mathematics education that can enhance student learning and understanding of mathematical concepts (Graham & Perin, 2020). Writing promotes the development of critical thinking, problem-solving, and communication skills, which are crucial for success in both math and other fields (Cox & Kelly, 2020). According to a recent study by Krupa and Horzela (2021), integrating writing assignments into math classes can improve students' engagement, motivation, and interest in the subject. Furthermore, writing

can provide an opportunity for students to reflect on their learning and make connections between different mathematical ideas (Ward, 2020). Therefore, it is important for mathematics instructors to incorporate writing assignments into their teaching practices to support students' mathematical learning and enhance their overall academic performance.

Incorporating writing activities into mathematics instruction can help students better understand and apply mathematical concepts (Cai et al., 2019; Ramos et al., 2020). According to Cai et al. (2019), students who wrote about mathematical concepts demonstrated greater understanding of the material compared to those who did not engage in writing activities. Similarly, Ramos et al. (2020) found that writing activities helped students develop critical thinking skills, leading to deeper understanding and application of mathematical concepts. Writing in mathematics also allows students to visualize the problem-solving process and draw conclusions from their solutions (Yıldırım et al., 2019). Additionally, writing in mathematics may improve students' writing skills in general, as the structured nature of mathematics may help students learn how to organize and structure their thoughts when writing in other classes (Cheng et al., 2021). Finally, teachers can benefit from student writing as it provides insight into students' comprehension of mathematical material, enabling teachers to better diagnose and address errors in students' thinking (Cho and Speer, 2020).

A study by Kim and Choi (2020) found that writing-to-learn activities, such as summarizing and reflecting on mathematical concepts, helped students better understand and retain the material. In a study by Skelton, Swarat, and Shaffer (2019), students who participated in writing activities that required them to explain and justify their reasoning in mathematical problem-solving demonstrated greater improvement in their mathematical reasoning skills than those who did not participate in such activities. According to a study by Jiang, Gong, and Xu (2019), writing in mathematics can improve students' metacognition, or their ability to reflect on and regulate their own learning. Writing activities in mathematics can also help students develop a growth mindset, or the belief that intelligence can be developed through effort and learning (Fyfe, 2019).

The above mentioned studies suggest that incorporating writing into mathematics instruction can benefit students in various ways, from improving their understanding of mathematical concepts to developing valuable skills such as metacognition and a growth mindset.

Writing is a powerful tool for learning and is particularly valuable in mathematics education. Writing can help students comprehend and apply mathematical concepts, see problem-solving steps, and draw conclusions and interpretations from the solution. It can also improve students' writing skills in general, and written explanations of a student's problem-solving process can help teachers diagnose and address errors in a student's thinking or knowledge of a concept.

What Writing Activities Can be Incorporated in Mathematics Classes?

Writing is a valuable tool for students in mathematics classes as it can reveal attitudes, anxieties, and beliefs that may hinder their learning. Writing tasks can help students express their concerns and help teachers offer a quick and caring response, which can motivate the student and strengthen the student-teacher relationship. Writing mathematics can be more troublesome than reading mathematics because students must generate understanding in another person, requiring a greater understanding of the content and better communication skills. Sipka (1990) suggests two types of writing assignments: informal and formal. Informal writing, such as free writing, mathematics autobiographies, journals, and reading logs, can help students understand the material, and the teacher can respond in a positive and caring way. Formal writing, such as letters to authors, proofs, formal lecture notes, and research papers, can be evaluated for content and writing quality, improving students' logical structure and proofreading skills.

Journals are an effective mode of dialogue, allowing students to ask probing questions and explain the material in depth to the teacher. Students can use the dialogue to communicate their concerns, misunderstandings, and difficulties regularly to the teacher. Teachers must give students a clear understanding of keeping a journal, allow class and homework time for journal writing, and use journals over several years as a means of assessment. Writing letters to teachers, authors, and fellow students, and rewriting lecture notes can also improve students' writing skills. Students can improve their clarity and structure when they know they are writing for an audience.

Although many teachers recognize the importance of writing in fields other than English, its use as a learning tool in mathematics was met with resistance from many mathematics teachers. They believe that mathematics revolves around numbers and that writing is an activity that is simply not done in mathematics. However, writing can help students understand and communicate mathematical concepts, improve their logical structure, and proofreading skills. By incorporating writing assignments, teachers can help students learn better and establish positive teacher-student relationships.

Writing tasks can reveal attitudes, anxieties, and beliefs that may hinder student learning, and informal and formal writing assignments can be used to help students understand mathematical concepts and improve their writing skills. Writing can also improve logical structure, proofreading skills, and establish positive teacher-

student relationships. While many mathematics teachers have resisted incorporating writing into their teaching, it is an effective tool that can help students learn and communicate their understanding.

Writing allows the student to express comments, concerns or questions about what is being read. It gives the student the privilege of expressing the concepts in a personal way that might be easier to understand, and it allows the student to organize the topics in a way that makes sense. By writing short notes in the margins, students can easily return to recall what was read, make connections to material located in other areas of the book, and state their thoughts on the topic. Unfortunately, students are seldom allowed to write in textbooks.

Several literature suggest that writing activities can enhance student learning, aid in diagnosis and remediation, and help create more favorable attitudes toward mathematics. Using writing in developing higher cognitive skills and problem-solving abilities has been particularly highlighted. Writing activities such as explaining and word problems help students reflect on their reasoning, explore and clarify their thinking, and provide immediate feedback for review and reflection. Teachers can examine student thinking processes through writing and detect misconceptions more easily. Research supports the use of writing activities in mathematics, with findings showing improved problem solving, increased understanding, and better evaluation and remediation of individual students. Writing prompts and journals can also contribute to positive influences on student-teacher interactions and classroom atmosphere, and changes to and improvements in instructional practices. Writing activities should be used two or three times each week for maximum effect, as using writing less than once each week has little impact on students. Current mathematics curriculum documents suggest that teachers should use writing activities in their mathematics programs.

While publications give the impression that writing activities are being extensively used in mathematics classrooms, literature search reveals that only few studies have been directed at attempting to assess the degree of usage in this discipline. Other studies examined writing usage in content area subjects. However these studies provided little information relating to the frequency of writing usage in mathematics. This research deficiency prompted the investigation being reported here. Although there is strong support for the use of writing as an aid in the teaching of mathematics, it appears that no study has been conducted to determine the extent of its usage in Philippine schools.

Specifically, this study investigated the following: the profile of the teacher respondents, their frequency of use of writing activities in Mathematics teaching and learning and the differences in the respondent's extent of use of writing activities in their Mathematics classes when grouped according to their profile variables.

RESEARCH METHOD

Research Design

The study made use of the descriptive comparative research design. The descriptive component of the study is the examinations of the profile of the respondents and their frequency and extent of use of the various writing activities in Mathematics classes. On the other hand, the comparative component is the investigation whether there is significant difference in the extent of use of the different writing activities in Mathematics when respondents are grouped according to their profile variable.

Sample and Sampling Technique

A sample consisting of 21 schools all over Cagayan were considered in this study. Set of questionnaires were sent to the mathematics subject coordinators. Seventy three teachers from the twenty one schools returned the completed questionnaires. All participating schools are public high schools in Cagayan.

Instrument

In this research, Swinson and Kevan's survey questionnaire from 1992 was utilized with some revisions. The questionnaire comprised six commonly recommended writing activities that can be integrated in math classes, which include impromptu writing prompts, summarizing, essays, journaling, rewriting, and letter writing. Impromptu writing prompts: These are short, informal writing exercises that require students to respond to a specific question or prompt related to a mathematical concept or problem. Journal writing. Students can be asked to keep a math journal where they reflect on their learning, discuss their thought processes, and articulate their reasoning. Letter writing: Students can write letters to explain a mathematical concept to someone else, such as a friend or family member who is unfamiliar with the topic. Summarizing: Students can be asked to summarize a mathematical concept, theorem, or problem-solving strategy in their own words. Essays: Essays can be assigned that require students to explore a mathematical concept in depth, analyze its applications, or connect it to real-world problems. Rewriting: Students can be asked to take a poorly written mathematical proof or explanation and rewrite it in a clear and concise manner. Any other: This category allows for any additional writing activities that the teacher may use in their math class, such as collaborative writing assignments or research projects.An additional category called "any other" was also included in the list to assess the extent of writing activity use. The questionnaire consists of two parts. Part A collected profile data of the respondents while part B began with an introduction that stated the research objective and gave a brief overview of writing

in mathematics. Each of the seven categories was described, and teachers were requested to indicate how frequently they employed each writing category by marking the corresponding box labeled with "never," "less than five times a semester," "five to ten times a semester," and "each week."

RESULTS AND DISCUSSION

This chapter presents the findings of the study and provides an in-depth analysis and interpretation of the results.

Table 1 shows the distribution of respondents based on their gender, highest educational attainment, years in service and whether they received training in using writing activities in Mathematics instruction. Out of the 73 respondents, 30 or 41.1% were male while 43 or 58.9% were female. In terms of the highest educational attainment, 22 or 30.1% had a BS degree, 47 or 64.4% had a Master's degree, and only 4 or 5.5% had a PhD. Regarding years in service, 22 or 30.1% had 0-10 years, 27 or 37.0% had 11-20 years, 19 or 26.0% had 21-30 years, and only 5 or 6.8% had 30 years or more. Moreover, 90% of the respondents did not receive any training in using writing as a tool in Mathematics teaching and learning while 10% received training in using writing as a tool in Mathematics teaching and learning.

In a nutshell, the table shows that the majority of the respondents were female, had a Master's degree and did not receive any training in the use of writing in a Math class. It also shows that the respondents were relatively experienced, with most of them having more than 10 years of service.

Profile of the Respondents

Table 1. Respondents' Profile

Profile Variable	Frequency	Percent
Gender		
Male	30	41.1
Female	43	58.9
Highest Educational Attainment		
BS Degree	22	30.1
Master's Degree	47	64.4
PhD	4	5.5
Years in Service		
0 – 10 years	22	30.1
11 – 20	27	37.0
21 – 30	19	26.0
30 and above	5	6.8
Received Training in Writing Yes	7	10
No	66	90

Table 2 shows the frequency of use of the different writing activities used in math teaching and learning.

The table clearly shows that letter writing is never used by all teacher respondents in their mathematics teaching, as indicated by the frequency of 73 in the never column. The table also reveals that majority of the respondents never use the seven writing activities identified.

Among the different writing activities, only Journal writing is used on a weekly basis by 9 out of the 73 teacher respondents. On the other hand, 5 teacher respondents make use of journal writing five to ten times per quarter while 3 teacher respondents use other writing activity five to 10 times per quarter. Writing activities that were used by the teacher respondents for less than five times in a quarter include journal writing, essay writing, summarizing, rewriting and impromptu writing prompts with frequencies of 12, 8, 5,3,3, and 2 respectively.

Overall, the table suggests that writing activities are not commonly used in math classrooms. The majority of the teachers surveyed do not use any writing activities or use them infrequently. This may indicate a need for more professional development or support for teachers to help them understand the value of incorporating writing into math classes and to help them develop effective strategies for doing so.

Table 2:Frequency of Use of the Different Writing Activities in Mathematics (n = 73)

Writing Activity	Never	Less Than 5 Times In a Quarter	5 to 10 times a Quarter	Each Week
Impromptu/ Writing prompts	71	2	0	0
Summarizing	68	5	0	0
Essay writing	65	8	0	0
Journal writing	47	12	5	9
Rewriting	70	3	0	0
Letter writing	73	0	0	0
Any other writing activity	67	3	3	0

Table 3 shows the extent of use of different writing activities in mathematics and their corresponding mean scores. As can be gleaned from the table, the mean score for each writing activity is relatively low, ranging from 1.00 to 1.67, which indicates that the frequency of use is generally low. Specifically, "Letter writing" and "Impromptu/Writing prompts" have a mean score of 1.00, which means that they are never used in the context of mathematics teaching. "Summarizing," "Rewriting," and "Essay writing" have mean scores slightly above 1, indicating they are rarely used. "Journal writing" and "Any other writing activity" have the highest mean scores of 1.67 and 1.21, respectively, indicating that they are used but still at a relatively low frequency.
Overall, this table suggests that the use of writing activities in the teaching of mathematics is not yet widely adopted, and there is room for improvement in integrating writing into mathematics instruction.

Table 3:Extent of Use of the Different Writing Activities in Mathematics

Writing Activity	Mean	Interpretation
Impromptu/ Writing prompts	1.03	Never
Summarizing	1.08	Never
Essay writing	1.11	Never
Journal writing	1.67	Rarely
Rewriting	1.04	Never
Letter writing	1	Never
Any other writing activity	1.21	Never

Table 4 presents the results of the tests of difference in the extent of use of writing activities in Mathematics classes when grouped according to the teachers' profile variables, namely gender, highest educational attainment, years in service and whether they received training in writing.
With respect to gender, the mean extent of use of writing activities is slightly higher for females than males, but the computed t-value is very small and the p-value is greater than 0.05, which means that the null hypothesis is accepted indicating that there is no significant difference between the groups.
For the highest educational attainment, the mean extent of use of writing activities is highest for teachers with doctoral degrees, but the computed F-value is less than 1 and the p-value is greater than 0.05, which means that the null hypothesis is accepted indicating that there is no significant differences among the groups.
In terms of years in service, the mean extent of use of writing activities is highest for teachers with 0-10 years of service, and the computed F-value is 2.751 with a p-value of 0.0479, which is less than 0.05. Therefore, the null hypothesis is rejected, indicating that there is a significant differences among the groups. Specifically, teachers with 0-10 years of service use writing activities significantly more than teachers with over 30 years of service as revealed by the multiple comparison test (post-hoc).
With respect to the variable, whether teachers received training in writing, the computed t-value was 2.376 and a p-value of 0.049 which means that the null hypothesis is rejected, indicating that there is a significant difference between the groups. Specifically, teachers who received training in writing, use writing activities significantly more than teachers who did not receive such training.

Table 4:Comparison of the Extent of Use of Writing Activities in Mathematics

Extent of Use of Writing Activities		Mean	Computed Value	p-value	Decision
Gender	Male	1.10	t = 0.267	0.965	Accept Ho
	Female	1.15			
Highest Educational Attainment	BS Degree	1.11	F = 0.840	0.474	Accept Ho
	Master's Degree	1.18			
	Doctoral Degree	1.19			
Years in Service	0-10	1.29	F = 2.751	0.0479	Reject Ho
	11-20	1.12			
	20-30	1.11			
	Above 30	1.05			
Received Training in Writing	Yes	1.49	T = 2.376	0.049	Reject Ho
	No	1.12			

CONCLUSION

In conclusion, the study reveals that the use of writing activities in the teaching of mathematics is not yet widely adopted, with the mean scores of each writing activity indicating a relatively low frequency of use. The majority of the respondents were female, had a Master's degree, and did not receive any training in writing for math classes. The results of the t and F tests show that there is no significant differences in the extent of use of writing activities in Mathematics classes based on gender and highest educational attainment, but there are significant differences when it comes to years in service and training in writing. Teachers who received training in writing use writing activities significantly more than those who did not, while teachers with 0-10 years of service use writing activities significantly more than those with over 30 years of service.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations can be made:

1. Professional development programs should be organized and provided for teachers in mathematics to help them understand the value of integrating writing activities into their teaching. Specifically, these programs should target teachers who have been in service for over 30 years, as they were found to use writing activities less frequently than their less experienced counterparts.
2. School administrators should consider providing training in writing for teachers in mathematics classes. This could be done in the form of workshops or seminars, and could be offered to all teachers or specifically targeted at those who have not received such training.
3. Curriculum developers and instructional designers should consider integrating more writing activities into mathematics curricula. This could include incorporating writing prompts or assignments into math homework, quizzes, and exams.
4. Further research should be conducted to determine the most effective strategies for incorporating writing activities into mathematics instruction. This could involve examining best practices from other subject areas or looking at innovative approaches used by individual teachers.
5. Students in mathematics classes could benefit from increased opportunities for writing, as research has shown that writing can improve their understanding of mathematical concepts. Therefore, educators should consider incorporating more writing activities into their instruction to enhance students' learning outcomes.

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