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An Examination of Written Work and Performance Task in General Mathematics and Precalculus of Filipino STEM Learners

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Abstract: An Examination of Written Work and Performance Task in General Mathematics and Precalculus of Filipino STEM Learners. Objectives: This study examined the correlation between written work (WW) and performance task (PT) scores in general mathematics and precalculus of Filipino STEM learners at one public senior high school in the provincial capital of Leyte, Philippines, and compared the WW and PT scores of male and female learners. **Methods:** The quantitative approach using correlational and comparative designs was used to analyze the data obtained from the WW and PT scores of the 119 STEM learners (58 males and 61 females). **Findings:** Findings revealed a moderately positive and highly significant correlation between WW and PT scores of STEM learners. The difference in the WW and PT scores between male and female groups likewise displayed statistical significance, with the female group performing higher in WW and PT than their male counterparts. **Conclusion:** The development of state-of-the-art teaching strategies and practices can be utilized as input geared towards improving mathematics teaching and Filipino STEM learners' mathematics performance.

Keywords: Filipino STEM learners, general mathematics, performance tasks, precalculus, written work.

Abstrak: Ujian Tertulis dan Unjuk Kerja dalam Matematika Umum dan Prakalkulus bagi Pelajar STEM Filipina. ***Tujuan:*** *Studi ini menguji korelasi antara skor karya tulis (WW) dan tugas kinerja (PT) dalam matematika umum dan prakalkulus pelajar STEM Filipina di salah satu sekolah menengah atas negeri di ibu kota provinsi Leyte, Filipina, dan membandingkan WW dan PT jumlah siswa laki-laki dan perempuan.* ***Metode:*** *Pendekatan kuantitatif menggunakan desain korelasional dan komparatif digunakan untuk menganalisis data yang diperoleh dari skor WW dan PT dari 119 pelajar STEM (58 laki-laki dan 61 perempuan).* ***Temuan:*** *Temuan mengungkapkan korelasi yang cukup positif dan sangat signifikan antara skor WW dan PT pelajar STEM. Perbedaan skor WW dan PT antara kelompok laki-laki dan perempuan juga menunjukkan signifikansi statistik, dengan kelompok perempuan berkinerja lebih tinggi di WW dan PT daripada rekan laki-laki mereka.* ***Kesimpulan:*** *Pengembangan strategi dan praktik pengajaran mutakhir dapat digunakan sebagai masukan yang diarahkan untuk meningkatkan pengajaran matematika dan kinerja matematika pelajar STEM Filipina.*

Kata kunci: *pelajar STEM Filipina, matematika umum, prakalkulus, tes unjuk kerja, ujian tertulis.*

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INTRODUCTION

Senior High School (SHS) curricula across the globe sought to equip learners with the knowledge and skills necessary to meet the demands and expectations of the 21st century. Viro and Joutsenlahti (2020) mentioned that 21st-century attributes are crucial for a learner to succeed at school and in the workplace. Consequently, STEM (Science, Technology, Engineering, and Mathematics) learners must also possess these attributes as they play a critical role in any country's industrial and economic developments. School teachers were then required under K–12 basic education policies to foster a proactive learning atmosphere and to provide learners with relevant learning opportunities (Albay & Eisma, 2021). Furthermore, STEM education, being one of the most essential and in-demand professions (Maksimoviæ, 2020), aims to encourage learners to pursue STEM careers (Cabuquin, 2022a) to solve real-world problems (Mutambara & Bayaga, 2021) and actively participate in STEM-related activities (Dönmez et al., 2022).

Moreover, many learners believe mathematics to be challenging and abstract; thus, teachers have been striving for strategies to inspire them in mathematics lessons (Chan & Reynolds, 2022). It is not adequate for learners to learn passively in lecture-based mathematics classrooms; they must actively engage in the educational process by pursuing real-world research learning. STEM learners can gain meaningful experience dealing with mathematics courses such as general mathematics and precalculus by working alongside and under the supervision of their teachers (Birney et al., 2021; Carver-Thomas & Darling-Hammond, 2019). Teachers must be able to determine whether learners' answers are right or wrong and identify concepts that may impede learning or promote understanding in mathematics (Talanquer et al., 2015). It is likewise essential that SHS mathematics teachers provide STEM learners with personally relevant and informative feedback (Vennix et al., 2017) that guides them through their learning process. The purpose is also to ensure that learners do well in various assessment forms (Rasmitadila et al., 2020), like the written work and performance task components.

In a classroom context, the Written Work (WW) component refers to the ability of learners to express their skills and knowledge in written forms, such as in the form of quizzes and unit tests. The learner can be given specific directions for improvement through the teacher's precise and informative written feedback (Li, 2014). When STEM learners take in-class or online quizzes frequently, they are compelled to attend class regularly, ensuring they get all mathematics learning content and develop effective studying routines (DePaolo & Wilkinson, 2014; Cabuquin, 2022b; Mingoa & Abocejo, 2021). Frequent quizzes are a well-recognized classroom practice that aids learners in creating positive learning habits (Gokcora & DePaulo, 2018; Saraspe & Abocejo, 2020). However, Nicol (2021) and Rapanta et al. (2020) noted that the accuracy of WW assessment depends on teachers' capacity to pay attention to the content of learners' responses, identify pressing issues, and come up with insightful predictions about the significant impediments learners experience in understanding the concepts being scored.

Further, the Performance Task (PT) component permits learners to showcase what they know and can do. The learners may be able to do performance-based activities (Viro & Joutsenlahti, 2020; Rodriguez & Abocejo, 2018) that can be measured in the form of demonstrations, group presentations, oral recitations, and research projects. Lazic et al. (2021) further specified instruction emphasizing active learner involvement and activities that motivate learners to investigate, collaborate with others, solve real-world problems, and link

mathematics with other content areas to yield better results. The development of mathematical activities, content, teaching, and learning are no longer predicated on the idea that learners are passive consumers of knowledge passed down by the teacher (Montenegro, 2020; Snowball & McKenna, 2017). While traditional assessments demand learners to memorize facts (Ajjawi et al., 2020; Villarroel et al., 2020) to choose an answer from a set of possible solutions, performance assessments enable learners to exhibit specific competencies and skills (Worrel et al., 2019; Yulianti & Sulistiyawati, 2020). When learners learn a process with a framework, they will be able to remember when and how to use it and apply it in new contexts (Arhin, 2015).

Because mathematics plays such an essential role in a STEM learner's educational journey, it necessitates the acquisition of solid cognitive standards. Regarding mathematics instruction, particularly in various mathematics courses offered in the STEM field, some learners do well in various forms of written assessment but need more confidence to demonstrate the concepts and skills learned. Meanwhile, it can also be seen that some are eager to be involved actively in the learning process and want to integrate and demonstrate their understanding of a topic in front of their classmates but are unable to exhibit the same amount of energy when it comes to written tests- taking. The phenomenon of STEM learners excelling on both sides of a coin can likewise be observed. However, Demo et al. (2021) asserted that studying mathematics can help someone develop high self-confidence and self-efficacy. In effect, the connections between concepts and principles must be made to make mathematics learning more of an intellectual challenge for learners and less of a memorization test.

Although studies about STEM education and learners' scholastic performance have been carried out, most originate from international settings, with just a limited number from the Philippine context, specifically on Filipino STEM learners. The scarcity of literature focusing on the learners' capacity to complete the tasks in writing or by demonstration prompted the researcher to look deeper into this area and investigate whether or not STEM learners' WW scores are related to their PT scores in mathematics courses. Hence, this study could provide insights for the SHS community to adapt to the state-of-the-art teaching strategies and practices to improve the quality of classroom instruction SHS schools can offer Filipino STEM learners. This study further contends that knowing the link between WW and PT scores facilitates better teaching and learning opportunities among STEM learners.

Given the rationale mentioned above, this study examined the correlation between WW and PT scores in general mathematics and precalculus of Filipino STEM learners at one public senior high school in the provincial capital of Leyte, Philippines, and compared the WW and PT scores of male and female learners. Specifically, this study determined the (1) levels of STEM learners' WW and PT in general mathematics and precalculus, (2) the correlation between the learners' WW and PT scores in general mathematics and precalculus, and (3) the difference between male and female learners' WW and PT scores in general mathematics and precalculus. The study advanced the null hypothesis of no significant correlation between WW and PT scores and no significant gender difference between WW and PT scores of the said mathematics courses.

METHODS

Research Design

This study employed the quantitative approach using correlational and comparative designs to address the study's objectives. The correlational method was used since the study examines the link between written work (WW)

and learners' performance task (PT) scores in the identified mathematics subjects. Meanwhile, the comparative method was utilized to analyze the variation in the mathematics WW and PT scores between male and female groups.

Research Locale

This study was conducted in one public senior high school in the provincial capital of Leyte, Philippines, directly supervised by the Department of Education (DepEd), Tacloban City Division. The said school was currently offering three SHS strands, namely the STEM (Science, Technology, Engineering, and Mathematics) strand under the academic track, Industrial Arts (IA) strand, and Home Economics (HE) strand, which is both under the technical-vocational-livelihood track. The school had 235 registered senior high school learners in the first semester of the academic year 2022-2023, 171 of whom were under the STEM strand, five were in the IA strand, and nine were under the HE strand. Furthermore, during the academic year, the school implemented the face-to-face instructional method for the first time since the start of the COVID-19 outbreak.

Ethical Considerations

Before data retrieval, the researcher made a request letter to the school head to ensure ethical norms in collecting the necessary data. Together with the request letter is the rationale explaining the purpose of the study. Upon securing approval, the letter was shown to the mathematics teachers to request a copy of the STEM learners' WW and PT records in general mathematics and precalculus subjects. The data received was then placed in a Google Drive folder that was only available to the researcher. Furthermore, the researcher assured that the documents obtained were used solely for the study's objectives, and the learners' anonymity was treated with the utmost confidentiality.

Data Gathering Procedure

The WW and PT scores of the STEM learners in general mathematics and precalculus subjects obtained from the mathematics teachers' class records served as the primary sources of the secondary data. The study included only the STEM learners' general mathematics and precalculus subjects' WW and PT scores since these were the only mathematics subjects offered in the academic year's first semester, based on the STEM learners' subject checklist. In addition, from the 171 total STEM learners and using Cochran's Formula for calculating sample size, the study accumulated 119 learners' WW and PT records (58 males and 61 females) in general mathematics and precalculus, determined using simple random sampling. The learners' midterm and final term WW scores in the two mathematics subjects were computed to reflect their average. The study likewise calculated the average rating of the learners' PT scores in midterm and last term.

The Shapiro-Wilk test was performed to ensure the normality of the collected WW and PT scores of the STEM learners. The test showed no evidence of non-normality for the WW scores ($W = 0.98$, p-value $= 0.19$) and PT scores ($W = 0.99$, p-value $= 0.26$) in general mathematics. Based on this outcome, and after visual examinations of the histograms of WW and PT scores in general mathematics, a parametric test was used to correlate the two scores. However, the test statistic for precalculus showed that the distribution of the variable departed significantly from normality for the WW scores ($W = 0.94$, p-value $= 0.00$) and PT scores ($W = 0.97$, p-value $= 0.02$). Based on this outcome, and after visual examinations of the QQ plots for

WW and PT scores in precalculus, a non-parametric test was used to correlate the two scores.

Data Analysis

Tabular presentations summarized the collected WW and PT scores in general mathematics and precalculus. The study used simple frequency counting and percentages to determine the levels of WW and PT scores in general mathematics and precalculus. In addition, the Pearson correlation coefficient (Pearson r) examined the correlation between the learners' WW and PT scores in general mathematics. In contrast, Spearman's rank correlation coefficient (Spearman's rho) analyzed the link between WW and PT scores in precalculus. Meanwhile, the Mann-Whitney Wilcoxon Test was used to investigate the variations between the male and female learners' WW and PT scores in precalculus and the two-sample t-test for the variations between the male and female learners' WW and PT scores in general mathematics. The statistical analyses of data were formally done using *"Statistical Package for the Social Sciences"* (SPSS) software version 16.0.

RESULTS AND DISCUSSION

The succeeding tables present the WW and PT scores in general mathematics and precalculus of STEM learners.

Table 1. Levels of stem learners' written work and performance tasks in general mathematics and precalculus

	General Mathematics				Precalculus			
Description	WW		PT		WW		PT	
	F	%	F	%	F	%	F	%
Outstanding	39	32.77	119	100.00	65	54.62	119	100.00
Very Satisfactory	32	26.89	-	-	25	21.01	-	-
Satisfactory	33	27.73	-	-	13	10.92	-	-
Fairly Satisfactory	9	7.56	-	-	10	8.40	-	-
Did Not Meet Expectations	6	5.04	-	-	6	5.04	-	-

N = 119

Score Range	*Description*
90.00-100	*Outstanding*
85.00-89.99	*Very Satisfactory*
80.00-84.99	*Satisfactory*
75.00-79.99	*Fairly Satisfactory*
< 75	*Did Not Meet Expectations*

General Mathematics
WW Mean Score = 86.39 (Very Satisfactory) with SD. = 6.22
PT Mean Score = 96.60 (Outstanding) with SD. = 1.52

Precalculus
WW Mean Score = 89.67 (Very Satisfactory) with SD. = 7.49
PT Mean Score = 94.70 (Outstanding) with SD = 1.39

As shown in Table 1, the mean score (86.39, 89.67) for WW performance in general mathematics and precalculus was interpreted to be "very satisfactory." This implies that STEM learners could express their knowledge and skills in written work activities (i.e., quizzes or tests) provided by their subject teachers. Results also revealed that the mean score (96.60, 94.70) for PT in general mathematics and precalculus was interpreted as "outstanding." This means that the

learners could demonstrate and integrate the concepts and skills they learned about the lessons. Their outstanding performance is also attributed to their inclination in general mathematics and precalculus and their willingness to excel in their chosen strand. The PT scores' standard deviation (1.52, 1.39) further indicates that the learners' performance is relatively consistent and clustered around the mean score. Blotnicky et al. (2018) indicated that high school learners with higher academic goals are more likely to be drawn to STEM fields. On the other hand, Sithole et al. (2017) noted that receiving external benefits from parents for good grades on a regular basis lowers learners' likelihood of pursuing STEM.

Table 2. Correlation analysis between ww and pt in general mathematics and precalculus

Group		Spearman's rho	
		r_s	p
General Mathematics	Written Work / Performance Task	0.532*	0.000
		Pearson r	
		r	p
Precalculus	Written Works / Performance Tasks	0.516*	0.000

**Significant at the 0.01 level (2-tailed); N=119*

Table 2 presents the correlation analysis between the STEM learners' WW and PT scores in general mathematics and precalculus. The Spearman's rho result for general mathematics led to a p-value of 0.000, indicating a moderately positive and highly significant correlation (rs = 0.532, á < 0.01) between the WW and PT in general mathematics. This implies that the higher learners' performance in WW, the higher their PT score. Meanwhile, the lower learners' performance in WW, the lower their PT score. In addition, the Pearson r result for precalculus exhibited a p-value of 0.000 which is significant at 0.01 alpha. This means there is a moderately positive and highly significant correlation (r = 0.516, á < 0.01) between the WW and PT in precalculus. This further implies that the higher the performance of learners in WW, the higher their PT score, whereas the lower the performance of learners in WW, the lower their PT score. Harackiewicz and Priniski (2018) indicated that frequent quizzes could be crucial for improving learners' performance. This backs up the findings of Gokcora and DePaulo (2018), who discovered that frequent assessment models, such as frequent quizzes, mitigate the achievement gap between learners.

Table 3. Two-sample t-test between ww and pt in general mathematics according to gender

Group		N	Mean	SD	Two-Sample T-test	
					t	p
General Mathematics WW scores	Male	58	85.10	7.49	-2.248***	0.026
	Female	61	87.62	4.44		
General Mathematics PT scores	Male	58	96.01	1.79	-4.415**	0.000
	Female	61	97.16	0.91		

***Significant at the 0.01 level (2-tailed); ***Significant at the 0.05 level (2-tailed)*

Table 3 displays the difference between the male and female learners' WW and PT in General Mathematics. As reflected in the table, the Two-Sample T-test result revealed the difference in the general mathematics WW scores between male and female groups and is statistically significant (á < 0.05) as described by the p-value of 0.026. This means there is a difference between the WW scores of male and female learners in general mathematics. Further, the difference in the PT scores between male and female groups likewise demonstrated statistical significance (á < 0.01), indicating a variation in the general mathematics PT scores of male and female learners.

The disparity between the WW and PT scores of the two groups may be influenced by their motivation to accomplish the tasks assigned by their teachers. According to Akpotor and Egbule (2020), additional teaching methods and motivational strategies should be used to improve both male and female learners' performance. Lin et al. (2021) further emphasized that the teachers' teaching approach could also impact both male and female learners' performance, intelligence, and motivation. Meanwhile, Kemmelmeier and Walton (2016) reported that females out performed males in terms of the authenticity of their creative efforts. The study finding likewise corroborates with that of Quadlin (2018), who asserted that females consistently achieve higher marks than males at all educational levels.

Table 4 shows the difference between the male and female learners' WW and PT scores in general mathematics and precalculus according to gender. The Mann- Whitney U test result displayed a Z-value of -3.707 and a p-value of 0.000, suggesting a significant difference between the precalculus WW scores of male and female groups. The result further illustrates that the female group performs better in WW than their male counterpart, as evidenced by the mean rank of 71.43. This may imply that female learners practice test-taking skills and prepare for written activities ahead of time compared to male learners. For the precalculus PT scores, the result showed a Z-value of -3.394 and a p-value of 0.001, exhibiting a significant difference between the precalculus PT scores of male and female groups. With the female group having a higher mean rank of 73.05, the result shows that females significantly have better PT scores than males. This may indicate that female learners may be more competent and involved in the learning process than male learners.

Table 4. Mann-whitney u test between ww and pt in precalculus according to gender

Group		N	Mean Rank	Mann-Whitney U test	
				Z	p
Precalculus WW scores	Male	58	47.98	-3.707**	0.000
	Female	61	71.43		
Precalculus PT scores	Male	58	49.01	-3.394**	0.001
	Female	61	73.05		

***Significant at the 0.01 level (2-tailed)*

Moreover, the finding of this study differs from that of Chan and Reynolds (2022), who revealed that female learners tend to be less interested, anxious, and less confident in their mathematical abilities. However, recent research showed contrasting views regarding how well learners succeed in academic fields such as mathematics and science based on gender (Turhan, 2020; Pollanen et al., 2018; Jacobson

et al., 2022). While some backed females over males in terms of academic achievement at the primary and junior levels, other studies found males to outperform their counterparts, particularly in mathematics at the higher education level. Meanwhile, Younes et al. (2020) and Baliram and Ellis (2019) also indicated that learners do not significantly differ in gender and academic progress.

CONCLUSIONS

The study examined the correlation between written work (WW) and performance task (PT) scores in general mathematics and precalculus of Filipino STEM learners. Given the results, higher learners' performance in WW means higher PT scores, whereas lower performance in WW indicates lower PT scores in general mathematics and precalculus disciplines. Meanwhile, the difference between the WW and PT scores of male and female STEM learners in general mathematics and precalculus may be influenced by their motivation to accomplish the tasks assigned by their teachers. Mathematics teachers can design pedagogical approaches that make it easier for learners to comprehend the core ideas they need to learn without compromising the caliber of mathematics instruction in the classroom. The STEM learners' exposure to problem-solving and empowering them to explain their solutions helps them become more proficient at comprehending both the conceptual and procedural aspects of learning. Both learners' abilities to excel not just through written forms but also in exhibiting their ability to communicate their comprehension can be developed by the balanced provision of WW and PT activities in the classroom.

For STEM learners to meet the demands of 21st-century education, they must also be provided equal opportunities to succeed in a learning environment, and teachers must continue to strengthen their intellectual capacities. In addition, the school administration must give mathematics teachers adequate support and resources; each must be given manageable tasks to devote more time to enhancing learners' cognitive abilities and maximizing their instructional time. This study also considers only two of the STEM learners' mathematics courses; including other core and specialized courses may provide a more comprehensive view of the link between WW and PT of STEM learners. Future research could be carried out by considering other significant aspects that should be addressed in this study, such as learners' motivation, subject preferences, and prior experiences in the STEM field.

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