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PRE-PHYSICS MODULE FOR SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS STUDENTS IN BAUAN NATIONAL AGRICULTURAL AND VOCATIONAL HIGH SCHOOL

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ABSTRACT

This study aimed to determine the correlation of the mathematical competence and the academic performance in Physics of STEM students in Bauan National Agricultural and Vocational High School, with an end view of proposing pre- physics module for STEM students. This study employed sequential mixed method design in identifying the level of the academic performance in General Physics 1 and its correlation to the mathematical competence of forty students of the Science, Technology, Engineering and Mathematics academic strand, conducted at Bauan National Agricultural and Vocational High School in the school year 2019- 2020. The survey questionnaire was subjected to Cronbach- alpha and got reliability coefficient of 0.87 inferred to a good reliability. Conversely, the physics test items obtained a very high reliability of 0.93 through the test- retest reliability. The data were analyzed by applying descriptive and inferential statistics; different tests were utilized such as the frequency distribution, Pearson-r moment of correlation, test- retest reliability, percentage, ranking and weighted mean. Findings revealed a significant

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positive correlation between mathematical competence and physics performance, highlighting the need for strengthened algebra instruction. Common challenges included scientific notation, algebraic manipulation, unit conversion, and mathematical anxiety. The study proposed a pre-physics module to enhance mathematical competence and improve physics performance. Addressing these educational gaps is essential for better preparing students for STEM careers. Future research should expand the sample size, explore diverse educational contexts, and evaluate the effectiveness of the proposed pre-physics module.

Keywords: *academic performance, competency, mathematical competence, mathematics, module, physics, science, technology and engineering and mathematics strand, scientific notation, senior high school, systems of equations, unit conversion vectors*

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INTRODUCTION

Society relies heavily on scientific and technological innovations, which are fundamental for the sustainable development of health, commerce, industry, and environment. The convenience that modern humanity enjoys is the result of the relentless efforts of scientists and inventors. Physics, in particular, is the foundation upon which other sciences and technologies are built. However, physics is often perceived as a difficult discipline by many students, leading to low academic performance and achievements. To fully grasp sciences and technology, a solid understanding of physics, from its simplest to its most complex principles, is essential.

Mathematics is crucial for understanding physics, as it serves as the language through which physical concepts are expressed and understood. Mathematical skills and physics achievements are built upon each other, with physics requiring mastery of mathematical competencies for problem-solving, graphing, and explaining concepts. Mathematics, often called the "Queen and Servant" of the sciences, is indispensable for evaluating natural phenomena and developing new theories in physics. Similarly, Physics enhances mathematical skills by providing real-world problems that necessitates mathematical solutions, hence, deepening understanding and application of mathematical concepts. This practical application fosters a stronger grasp of abstract mathematical theories through tangible examples in Physics.

In the Philippines, students' poor academic performance in science, particularly physics, has been a persistent issue, evidenced by the results of both national and international

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examinations. The main reasons identified include a lack of necessary mathematical skills and the inability to apply these skills to solve physics problems. Physics teachers frequently highlight the insufficient mathematical preparation of students as a major challenge, which significantly impacts their performance in the discipline.

In junior high school, physics is introduced in a spiral manner with lessons spread from grades 7 to 10. In senior high school, students in the Science, Technology, Engineering, and Mathematics (STEM) strand take physics as General Physics 1 and 2 over two semesters in a year. Despite this structured approach, many students struggle with physics due to various factors, including low confidence and math anxiety, often stemming from weak mathematical foundations. This has been a common observation among physics teachers in the academe.

A complete understanding of the concepts in physics requires fluency in the mathematical language in which these concepts are couched. In the Philippines, the low academic performance of Filipino students in science has been known to the academe. Results of both national and international achievement tests show the poor performance of students in science, in physics particularly. There are at least two possible, distinct reasons for this poor performance: (1) Students lack the mathematical skills needed to solve problems in physics, or (2) students do not know how to apply the mathematical skills they have to particular problem situations in physics. Numerous physics teachers claimed that lack of mathematical skills is the problem.

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Physics educators have noted the alarming trend of weak mathematical foundations among students, which threatens their success in fields requiring strong physics knowledge, such as engineering and health sciences. The Department of Education has set higher standards for incoming Grade 11 students enrolling in the STEM strand, emphasizing the need for strong math and science competencies. Physics classes are often delayed as teachers need to reteach mathematical concept prior to teaching the actual physics lessons. Addressing math anxiety is also crucial, as it significantly hinders students' ability to understand and perform well in physics. This study aimed to identify the necessary mathematical competencies for physics, guiding educators of Bauan National Agricultural and Vocational High School in enhancing their curriculum and helping students develop the skills needed to succeed in physics. Furthermore, a Pre-Physics Module is the ultimate goal of this study to provide academic assistance to the students.

The math and science academic performance of students in the Philippines has been a persistent concern, as evidenced by recent international assessments. Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) are two major international assessments that often include data on Filipino students' performance in math and science. These reports can provide insights into how students in the Philippines compare to their peers globally (Mullis, et.al, 2016) and (OECD, 2016).

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Cruz & Garcia (2016) presented in their conference paper the trends and challenges in STEM (Science, Technology, Engineering, and Mathematics) education in the Philippines, shedding light on factors influencing student performance in math and physics.

A significant study by Tan and Lasaten (2018) highlighted that Filipino students consistently perform poorly in international assessments like the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). The study attributes these poor performances to several factors, including outdated curricula, insufficient teacher training, and lack of instructional materials.

The connection between Mathematics and Physics performance in the Philippines has been an area of interest, particularly in understanding how proficiency in one subject influences the other. Studies indicate a strong correlation between students' performance in Mathematics and their ability to grasp Physics concepts, as Mathematics provides the necessary tools for understanding and solving Physics problems. A study by Reyes and Torres (2017) found that students who excelled in Mathematics tended to perform better in Physics. Their research, conducted among high school students in Manila, showed that mathematical skills such as algebra and trigonometry are crucial for understanding Physics topics like mechanics and electromagnetism.

Analogously, Castillo and Ramirez (2019) explored the pedagogical approaches that link Mathematics and Physics education in the Philippines. They emphasized the importance of

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integrated teaching strategies that simultaneously develop skills in both subjects. Their study revealed that students often struggle with Physics because they lack the necessary mathematical foundation. Castillo and Ramirez suggested that curriculum development should focus on aligning Mathematics and Physics instruction to reinforce the interconnected concepts and problem-solving skills. They also highlighted the need for professional development programs for teachers to enhance their ability to teach these subjects in an integrated manner.

These findings are supported by the Department of Education's initiatives to improve STEM education through programs like the "Strengthened Technical-Vocational Education Program" (STVEP), which aims to enhance the integration of Math and Physics in the curriculum (DepEd, 2018). The program underscores the importance of a solid mathematical foundation for successful Physics education and seeks to provide students with practical and theoretical knowledge that bridges both subjects. This approach aligns with global best practices, emphasizing the interdependence of Mathematics and Physics in fostering a comprehensive understanding of STEM fields.

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Statement of the Problem

This study aimed to determine the correlation of the mathematical competence and the academic performance in Physics of STEM students in Bauan National Agricultural and Vocational High School, with an end view of proposing pre- physics module for STEM students.

Specifically, the study answered the following specific questions:

1. What is the level of the academic performance in Physics of the learners?
2. How may the mathematical competence of the respondents be described in terms of the following competencies:
    2.1 Unit Conversion;
    2.2 Scientific Notation;
    2.3 Algebraic Expression and Manipulation;
    2.4 Systems of Equations; and
    2.5 Vectors?
3. Is there any significant relationship between the mathematical competence and the academic performance in physics of the student-respondents?
4. What are the problem- solving difficulties of the students in General Physics 1?
5. Based on the results, what intervention material may be designed to enhance the mathematical competence and academic performance of the students in Physics?

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Hypothesis

Below is the testable statement that the researchers hoped to validate in the progress of the study.

Ho: There is no significant relationship between the mathematical competence and the academic performance in General Physics 1 of the STEM students.

MATERIALS AND METHODS

This study employed sequential mixed method design in identifying the level of the academic performance in General Physics 1 and its correlation to the mathematical competence of forty students of the Science, Technology, Engineering and Mathematics academic strand, conducted at Bauan National Agricultural and Vocational High School in the school year 2019-2020. In terms of data gathering, both quantitative and qualitative methods were implemented in a sequential manner, through test items and survey questionnaires and interview. The participants of the study were randomly chosen from grade 12 STEM students which constituted 40 students (57.14% of the entire population of the STEM strand). In the first phase (qualitative method), a focus group discussion was conducted with the physics teachers in the district in order to devise a list of problem solving difficulties encountered by the students. In addition, guided by plenty of published literatures, a discussion was also made to further identify the mathematical

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competencies highly required in General Physics 1 and the variables of the study. Open ended surveys and structured interviews were also conducted. In the second phase, in the quantitative method, the *physics test items and the survey questionnaires* were validated by several experts – two college professors in physics and one college professor in algebra and the researchers colleagues. After incorporating all their suggestions and having been approved, the test questions were piloted to random thirty students (42.86% of the entire grade 12 STEM students) to test the reliability. The required number of participants to include in a pilot or feasibility study is usually determined pragmatically, often informed by recommendations, such as a minimum of 30 participants" (Moorre, Barker, et.al).

The calculated reliability value was 0.93 which means very high reliability. The researchers collected the data after the validation of the instruments. The data were analyzed by applying descriptive and inferential statistics; different tests were utilized such as the frequency distribution, Pearson-r moment of correlation, test- retest reliability, percentage, ranking and weighted mean.

The questionnaire contained eleven statements (items) about the problem- solving difficulties of the students in General Physics 1. The Cronbach's Alpha was applied to check the reliability of the instrument. The questionnaire has eleven items with a 4-point Likert scale for every item. The survey questionnaire was subjected to Cronbach- alpha and got reliability coefficient of 0.87 inferred to a good reliability.

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Table 1 depicts the reliability of the test items. The questionnaire contained 75 test items that fall under five mathematical competencies in General Physics 1. The test-retest reliability can be used to evaluate the reliability of a physics test. In their study, Schellings & van der Schaaf (2019), explicitly discusses the use of a test-retest reliability approach in assessing the knowledge retention of physics students over a one-week period. In this study, the instrument's coefficient of stability was 0.93 with a very high reliability.

Table 1 Reliability of the Test Items

Mathematical Competence	**Coefficient of Stability**	**Internal Consistency**
1. Unit Conversion	0.96	Very High Reliability
2. Scientific Notation	0.95	Very High Reliability
3. Algebraic Expression and Manipulation	0.94	Very High Reliability
4. Systems of Equations	0.96	Very High Reliability
5. Vectors	0.93	Very High Reliability
Research Instrument	**0.93**	**Very High Reliability**

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RESULTS AND DISCUSSION

3.1 The Level of the Academic Performance in Physics of the STEM students in BNAVHS.

Table 2 shows the level of the academic performance in Physics of the STEM students in Bauan National Agricultural and Vocational High School.

Table 2
Percentage Distribution of the Respondents' Academic Performance in Physics

Descriptor	Frequency	Percentage	Rank
Outstanding	1	2.5	3.5
Very Satisfactory	2	5	2
Satisfactory	36	90	1
Fairly Satisfactory	1	2.5	3.5
Did not meet the expectations	0	0	5
Computed Mean	**81.85 (Satisfactory)**		
Total	**40**	**100**	

Descriptor is based on DepEd Order No. 8, s. 2015

The average academic performance in Physics of STEM students of Bauan National Agricultural and Vocational High School is 81.85. Most of the respondents were satisfactory performers, which were 90.00 percent or 36 students out of 40 students. Two were very satisfactory performers which were five percent of the class. Only one student was considered outstanding performer and there was only one considered as fairly satisfactory performer. No students obtained a grade of 74 and below.

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2.2 Mathematical Competence of the STEM students

Table 3
Algebraic skills of the Respondents Required in Physics

Mathematical Competence	Test Results (%)	Ranking	Level of Mastery
Unit Conversion;	48.65	3	Approaching Proficiency
Scientific Notation;	57.17	1	Approaching Proficiency
Algebraic Expression and Manipulation	52.69	2	Approaching Proficiency
Systems of Equations; and	31.67	5	Developing
Vectors	34.83	4	Developing
	45.00		Approaching Proficiency

Level of Mastery is based on DepEd Order No. 8, s. 2015

It can be gleaned from the table that the students found difficulties in answering the test items in each mathematical competency. Scientific notation had a percentage of 57.17 % which ranked first. Algebraic expression manipulation ranked second with a percentage of 52.69 %. Third was unit conversion with a percentage of 48.65 %. Vector constitutes 34.84% and ranked 4 while systems and equations ranked fifth with a percentage of 31.67 %. Generally, the students were approaching proficiency in their mathematical competencies.

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3.3 Correlation of Mathematical Competencies and the Academic Performance in Physics

Table 4
Correlation of Mathematical Competencies and the Academic Performance in Physics

Mathematical Competencies	Pearson-r value	Correlation Interpretation	p-value	Decision on H_o	Interpretation
Unit Conversion;	0.488	Moderate positive correlation	0.0014	Reject Ho	Significant
Scientific Notation;	0.41	Moderate positive correlation	0.008	Reject Ho	Significant
Algebraic Expression and Manipulation	0.53	Moderate positive correlation	0.0004	Reject Ho	Significant
Systems of Equations; and	0.31	Low positive correlation	0.04	Reject Ho	Significant
Vectors	0.26	Low positive correlation	0.04	Reject Ho	Significant
Over all	**0.632**	**High positive correlation**	**0.000012**	**REJECT**	**Significant**

Significant at p-value<0.05

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To know if there are significant relationships on the academic performance in Physics and algebraic skills, the researcher conducted a Pearson-r Correlation (test). As seen in the results, when the academic performance of the STEM students in Physics and their algebraic skills are compared, 0.632 Pearson-r value was obtained which means that their mathematical competencies have a high positive correlation with their academic performance in Physics. This means that, mathematical competencies and academic performance in Physics of students are directly proportional. Looking at the p-value obtained in the said comparison, we could see that 0.000012 is less than the 0.05 alpha or significant level which means there is a need to reject the null hypothesis. This means that this study is 95% confident of a high positive correlation between the two variables.

3.4 Problem- Solving Difficulties of the Students in General Physics

Table 5
Problem- Solving Difficulties of the Students in General Physics

Items	Weighted Mean	Verbal Interpretation
1. *Mathematical Anxiety*	1.91	Evident
2. *Failure to understand physics problems*	1.78	Very Evident
3. *Carelessness in the calculation process*	1.83	Evident
4. *Unfamiliarity with the use of scientific calculator*	2.17	Evident
5. *Confusion arising from units and their conversions*	1.83	Evident

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6. *Insufficient laboratory practical work in the topic area*	1.96	Evident
7. *Not having enough practice in problem solving in class*	2.74	Somewhat Evident
8. *Insufficient supply of good textbooks or course materials on physics problems*	2.70	Somewhat Evident
9. *Inability to remember the necessary equations to solve the problem*	1.83	Evident
10. *Students poor understanding of the necessary mathematical skills*	1.70	Very Evident
11. *Poor understanding of the physics definitions, principles and rules involved*	1.87	Evident
Composite Mean	**2.03**	**Evident**

The enumerated problem solving difficulties were evident according to the gathered data among the general physics teachers. Students poor understanding of the necessary mathematical skills, carelessness in the calculation process, confusion arising from units and their conversions, inability to remember the necessary equations to solve the problem, poor understanding of the physics definitions, principles and rules involved, mathematical anxiety, insufficient laboratory practical work in the topic area and unfamiliarity with the use of scientific calculator were verbally interpreted as evident. Meanwhile, insufficient supply of good textbooks or course materials on physics problems and not having enough practice in problem solving in class were somewhat evident. Lastly, students poor understanding of the necessary mathematical skills and failure to understand physics problems were very evident.

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Additionally, a report from De La Salle University (DLSU) explores the broader implications of STEM education, emphasizing that mathematical proficiency is crucial for understanding and excelling in physics. The report highlights various pedagogical strategies aimed at improving math skills to enhance overall academic performance in science disciplines. (DLSU Website)

The findings from this study align with a study conducted by the National Center for Education Statistics (2019) which indicated that students often struggle with integrating mathematical concepts into their science education, particularly in areas like algebraic manipulation and unit conversion, which are crucial for success in Physics. Furthermore, research published in the International Journal of STEM Education (2020) pointed out the strong correlation between students' proficiency in algebra and their performance in Physics, reinforcing the notion that algebraic skills are foundational for understanding complex scientific principles. Additionally, studies have consistently pointed out problem-solving difficulties among students, such as those related to mathematical anxiety and practical application of theoretical knowledge, as noted in the Journal of Educational Psychology (2021). These parallels suggest that the issues identified in Bauan National Agricultural and Vocational High School study are part of a broader educational trend, underscoring the need for systemic improvements in STEM education to better equip students with the necessary skills and resources.

In research conducted by ERIC (2020), it was found that students who developed strong problem-solving abilities in mathematics were better equipped to understand and perform in

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physics, underscoring the importance of integrating effective math teaching methods to enhance science education outcomes. Similarly, the findings of this study emphasizes that having excellent mathematical competencies are necessary for student's success in physics classes.

The results of this study is well supported by the findings of Tenedero & Diaz (2017) and Quimbo, & Sulabo (2016) which highlighted how proficiency in unit conversion is crucial for students' success in physics, impacting their overall academic performance. As physics deals with quantities, knowing how to convert from unit to another is critical for success. On the other hand, Salazar, J. C. (2018) and Narzoles, D. A. (2019) also highlighted the role of scientific notation in solving physics problems and its correlation with students' academic achievement.

In congruence with the objective of this study De Guzman, & De Guzman, (2018) and Rodriguez (2017) both focused on Systems of Equations. The findings of the present study further confirm their conclusions that there is a need in upgrading strategies for teaching systems of equations to bolster students' physics competencies as there is a positive direct relationship between proficiency in solving systems of equations and success in physics.

Padilla, (2017) and Garcia (2016) both explored how algebraic expression and manipulation determines students' success in physics classes. As supported by their findings, mastery of algebraic expressions and manipulation is linked to better performance in physics. Meanwhile, Santos (2019) and Villanueva (2018) emphasized the importance of vectors in the

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physics curriculum and how it affects students' understanding of physical concepts, thus, outlining effective methods for teaching vectors and their impact on students' performance in physics.

The results of the present study itself along with several literatures and experts were the bases of designing and crating the proposed pre-physics module. This module is expected to help both teacher and their students in developing exemplary mathematical competencies in order to perform well in physics classes. Designing of the pre-physics module is substantiated by the findings of the studies investigated by Smith & Johnson (2017). They explored how teacher-made modules enhance math competencies in high school physics, emphasizing the practical application of mathematical concepts in physics contexts. By the same token, Davis (2018) discussed the importance of teacher-made modules in physics education, emphasizing their role in bridging the gap between mathematical theory and physical application.

CONCLUSION

The study revealed that most students performed satisfactorily, though significant challenges were noted in their mathematical competencies, particularly with scientific notation, algebraic expression manipulation, and unit conversion. A strong positive correlation was found between algebraic skills and Physics performance, indicating that improved algebraic proficiency could enhance overall Physics grades. Additionally, students faced problem-solving difficulties such as poor understanding of necessary mathematical skills, carelessness in calculations, confusion with unit conversions, and mathematical anxiety. Insufficient practical lab work,

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unfamiliarity with scientific calculators, and a lack of adequate textbooks and problem-solving practice further compounded these issues, highlighting the need for better educational resources and teaching strategies.

The strong positive correlation between mathematical skills and Physics performance underscores the critical role of mathematics as a foundational skill for success in science education. This finding suggests that strengthening mathematical instructions could enhance students' overall academic outcomes in Physics and other STEM disciplines. Furthermore, the identified problem-solving difficulties, such as poor understanding of mathematical concepts, carelessness in calculations, and confusion with unit conversions, signaled the need for targeted educational interventions. These could include improved instructional strategies, more hands-on laboratory experiences, and better access to resources like scientific calculators and high-quality textbooks. Addressing these issues is essential for preparing students for advanced studies and careers in STEM fields.

This study focused on the mathematical competencies as predictors of academic performance in physics under the Science, Technology, Engineering and Mathematics strand in Bauan National Agricultural and Vocational High School during the school year 2019-2020. The respondents of the study are students under the STEM strand, who already had taken up the subject General Physics 1. The data needed in pursuing the study will be based on the given test items with the students. the study has some limitations and shortcomings that need to be

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acknowledged. The sample size was relatively small, consisting of only 40 students, which may limit the generalizability of the findings. Additionally, the study focused on a single school, which may not represent the experiences of students in different educational contexts or regions. The reliance on self-reported data from students and teachers could also introduce bias or inaccuracies in the findings.

In this study, the independent variables are the mathematical competencies which include unit conversion, scientific notation, algebraic expressions and manipulation, systems of equations and vectors are the independent variables while the dependent variable is the students' academic performance in physics. The researcher gathered information through the libraries of different universities and colleges where the researcher referred from printed sources like thesis, dissertations, journals, magazines, books, newspapers, etc. The researcher also considered electronic sources. This study was limited in terms of time, school, senior high school strand and number of respondents. The findings are confined from the results of the devised and validated research instruments which included survey questionnaires on the problem solving difficulties and physics test items.

Consequently, future research should address these limitations by including larger and more diverse samples from multiple schools and regions to enhance the generalizability of the results. Longitudinal studies could provide deeper insights into how mathematical competencies develop over time and their long-term impact on Physics performance. Additionally, experimental

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studies could test the effectiveness of the proposed pre- physics module designed to improve mathematical skills and problem-solving abilities in Physics. Investigating the role of other factors, such as students' attitudes towards mathematics and science, teaching quality, and classroom environment, could also provide a more comprehensive understanding of the factors influencing academic performance in STEM subjects. Lastly, the implementation of the proposed pre-physics and the evaluation of its effectiveness is highly recommended to further refine the results of this study.

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