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Effectiveness of basic gymathics as a math development program in the maritime curriculum

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Abstract

This research assesses the Basic Gymathics program's effectiveness in enhancing maritime students' mathematical proficiency. Among the 358 respondents from LIMA, which included 263 BSMT and 95 BSMarE students, it is noteworthy that most of them have attained excellent final grades of 1.25 average. Paired sample t-tests show substantial post-test score improvements, ranging from 60.9% to 132.1%. These results emphasize the program's efficacy in enhancing mathematical skills and problem-solving abilities. The proposed action plan aims to tailor the curriculum for maritime students, provide training for instructors, and integrate the program into maritime school curricula to address word problem-solving challenges, aligning it with the objectives of the maritime curriculum.

Keywords: mathematics, maritime curriculum, basic gymathics, maritime student, maritime education

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1. Introduction

Mathematics is significant in the educational system across nations and academic levels. It is often characterized as a framework for fostering critical thinking, prompting students to carefully analyze and logically address problems and effectively communicate their ideas. Consequently, mathematics is a cornerstone of intellectual development and a crucial tool in various fields, including science, commerce, and technology (Oluwole & Muraina, 2016). Furthermore, mathematics is one of the major learning components in education because of its significant role in man's life. Man needs it to live intelligently in today's fast-changing technological environment. This also helps man to develop higher-order thinking skills that enable man to think critically and analytically to make decisions objectively. Thus, man needs sufficient knowledge of the basic mathematical concepts and principles to acquire the necessary skills to think analytically and critically in day-to-day activities. Moreover, mathematics is one of the oldest sciences used for various calculations in shipping, from shipbuilding to trade, transportation, and management. The safety of navigation, improvement of accuracy in navigation, optimization of costs, and higher earnings and profits for ship owners and employees pose only a fraction of maritime affairs, hardly accessible without the knowledge and applications of Mathematics (Tatjana Stanivuk, 2017).

Hence, the need for Mathematics and its role in maritime industrial performance remains more relevant than before. The introduction of modern, sophisticated equipment in the operations within the maritime industry lays credence to the assertion that the Mathematics curriculum must be redesigned to meet these changing trends squarely, especially in the face of the rapid growth within the industry (Akakpo, 2016). Thus, every Higher Education Institution that offers Maritime programs needs to comply with the requirements of the Commission on Higher Education that graduates of BSMT and BSMarE should be able to apply knowledge in mathematics, science, and technology in solving problems related to the profession and the workplace (CMO No. 67 series 2017). Furthermore, the importance of Mathematics in the maritime industry is also noted in the performance assessment for maritime students known as the Maritime School Assessment Program (MSAP). It aims to set a benchmark for Philippine Maritime Schools via a nationwide standard examination for all second-year students taking up Bachelor of Science in Marine Transportation (BSMT) and Bachelor of Science in Marine Engineering (BSMarE). The standard examination covers English, Mathematics, and fundamental Deck/Engine Technical subjects, each with a corresponding weight distribution. The MSAP seeks to identify the student's strengths and areas for improvement based on the test results and performance of students who took the examination.

As cited from the study of Dinglasan and Orence (2013), the mathematics performance of LIMA cadets on the MSAP is relatively low since the percentage is just almost 50 to 60 percent, which suggests that even though the students were improving, they need to study more and appreciate the importance of studying Mathematics subjects. Moreover, maritime students should do well in Mathematics since most professional subjects require computation and problem-solving skills. As supported by the findings of Dinglasan and Orence (2013), there is a significant relationship between the performance in Mathematics and Technical subjects. This denotes that performance in technical subjects can be a factor that determines performance in Mathematics.

Based on these contexts, there is a great need to improve the level of mathematics proficiency of maritime students, which is why LIMA included Basic Gymathics as a math development program in the maritime curriculum. Basic Gymathics covers basic math concepts and principles of arithmetic, algebra, and solid mensuration used in calculations related to the maritime field, such as speed, flow rate of pumps, and fuel requirements. In this course, the student should be able to apply the concepts of fractions, decimals, and percentages in solving problems related to mensuration and other maritime calculations; formulate algebraic

equations and use them to solve problems in mensuration, proportion, and other maritime calculations; use algebraic equations to solve for missing variables in speed, pump capacity, and fuel requirement problems; and lastly, derive the equations for calculating unknown variables in maritime-related calculations. The program's implementation started in the second semester of AY 2018–2019. This study aimed to determine the effectiveness of the program.

Objectives of the Research - The study aimed to evaluate the effectiveness of Basic Gymathics as a Math Development Program. Specifically, it aims the following objectives: (1) to identify the mathematics performance of BSMT and BSMarE students in Basic Gymathics; (2) to determine the significant difference between the math skills of the maritime students using pre-test and post-test methods; (3) to evaluate the effectiveness of Basic Gymathics in improving the mathematical proficiency skills of the maritime students; and (4) to propose an action plan for enhancement of the program based on the results.

2. Literature Review

2.1 Mathematics in Maritime Affairs

Maritime affairs can be defined as an activity including all actions either directly or indirectly connected with the sea. Maritime affairs include marine navigation and the conduct of ships and combine the concepts of ships, workers, and companies across the shipbuilding industry to trade, transport, and management. Many of the previously stated components in shipping are calculated using mathematics, one of the oldest sciences. Mathematics is used to tackle problems such as the stability of a tossing boat and financial budget applications in navigation. The safety of navigation, improving navigation accuracy, optimizing costs, and how ship owners and maritime affairs employees make more revenue and profit are only a fraction of maritime affairs that cannot be approached without knowledge and application of maritime affairs and mathematics (Stanivuk et al., 2017).

In addition, as cited by Gudelj et al. (2021) from the study of Stanivuk et al. (2017) and Akakpo (2016), students must have a good background in mathematics and statistics in order to complete maritime-related courses, as mathematics plays an integral part in maritime affairs. According to Qi, 2022, mathematics is a fundamental part of maritime training programs, as it is deeply involved in maritime affairs, e.g., ship stability and navigation, which are problems that computing can solve. As one of the oldest sciences, mathematics helps us with many maritime affairs calculations. Ship stability, swinging on the waves, dynamics of the vessel in towage, and navigation are just some of the problems that can be solved using mathematics (Stanivuk T. et al., 2017). Furthermore, mathematics helps us with many maritime affairs calculations, as cited by Padernal (2023) in the study of Stanivuk T. et al. (2017), state that differential equations (calculus) solve many problems connected with the navigation and motion of vessels. In the same study, the number of applications of trigonometric functions was very high. For instance, the triangulation technique is used in astronomy to measure the distance to close stars; in geography, it is used to measure distances between landmarks, and it is also used in satellite navigation systems. The sine and cosine functions are the basis of the theory of periodic functions, such as those that describe sound and light waves. In addition, differential calculus is also used to solve problems in marine engineering and naval architecture (cited by (Padernal, 2023; Liu et al., 2019).

Nevertheless, according to Shylaja (2015), one of the most challenging issues faced by navigators in the past was calculating distances when sailing on the sea. They relied heavily on trigonometry to aid them in this endeavor. Trigonometry gave them faster, more accurate methods and equations for calculating distances. The same calculations were used in a completely different subject - astronomy, for example, to determine the angular separation between stars or between planets and stars. What is remarkable is the startling similarities between solutions generated by people from various locations, backgrounds, and even eras. Additionally, Bowditch (2017) states that spherical trigonometry is essential in navigation for both airplanes and waterborne vessels of transportation. It is the fundamental foundation from which the practical application of the principle of Great

Circle Navigation comes, as the shortest distance between two points on a sphere is located along an arc of a great circle, critical to efficient navigation. In addition, spherical trigonometry has historically been one of the most critical areas of mathematics due to its apparent applications to astronomy and navigation, as stated by Wildberger (2018).

Moreover, navigation is taught to Sea Captain students in various courses as a mandatory study prescribed by the International Maritime Organization (IMO). Although, in modern times, voyage planning, on which the concepts discussed in this thesis heavily rely, is done exclusively using electronic aids and computerized programs, such as the Electronic Chart Display and Information System (ECDIS), it is still deemed necessary for students to understand the fundamentals of manually calculating passages using the concepts as mentioned earlier. (Tuomi, 2021). Therefore, mathematics and its role in the maritime industry's success are as vital as ever. The advent of new sophisticated equipment in maritime industry operations lends validity to the notion that mathematics curricula must be adjusted squarely to meet these shifting trends, especially in light of the industry's rapid expansion. Marine Education and Training practitioners are expected to keep track of the apparent significance of mathematics in the marine industry and design training programs to keep up with the global order (Akakpo & Ghana, n.d.).

2.2 Mathematics Performance of Maritime Students.

Based on the study results of (Manrique et al., 2018), most respondents were enrolled in the Bachelor of Science in Marine Transportation, with an average grade of 1.51-2.00 in Math. General education courses were found to affect the cadetship selection of maritime students, specifically in Mathematics. Moreover, the study of Padernal (2023) revealed that the level of academic performance of maritime students before the intervention was low in terms of the topic areas derivative and integral and when taken as a whole. However, there was a favorable increase in the results of their academic performance in the topic areas of derivative and integral and when taken as a whole after they were exposed to mnemonic-aided instruction. Specifically, they obtained an average level of academic performance after the intervention.

In addition, the study conducted by Abner et al. (2017) explores the relationship between maritime students' attitudes toward various school-related factors and their academic performance. The study is based on surveys conducted among maritime students in Lyceum International Maritime Academy, LPU-Batangas, and the findings highlight several key points:

- Firstly, concerning academic performance, it was observed that a significant portion of surveyed maritime students had academic performance levels ranging from low to average, indicating room for improvement in their scholastic achievements.
- Secondly, regarding their attitudes toward school-related factors, the students exhibited notably positive attitudes toward school facilities, followed by instructional materials and their peers. However, their attitudes toward teachers and the handling of classes were less favorable.
- Thirdly, regarding the facilities and learning environment at Lyceum International Maritime Academy, students enormously appreciated the state-of-the-art facilities, considering the learning environment conducive to their academic progress. This recognition highlights the potential positive impact of a well-equipped and comfortable learning environment on student engagement and motivation.
- Fourthly, the study established a positive correlation between students' attitudes toward teachers, class management, instructional materials, and academic performance. This finding underscores the potential for improved academic outcomes through positive perceptions of these crucial elements in the teaching and learning process.
- Fifthly, addressing teaching methodologies and approaches, the researchers recommended enhancing

interactive teaching methods to boost students' interest and active participation during class discussions. This shift in teaching style could lead to increased engagement and improved learning outcomes.

- Lastly, in faculty development, the researchers advised offering orientation and seminars for new maritime faculty members, focusing on pedagogical techniques tailored to maritime students' unique needs and characteristics. This specialized training can better equip instructors to teach effectively in this context.

Moreover, the study highlights the importance of students' attitudes toward various school-related factors in their academic performance. It underscores the significance of creating a positive learning environment, optimizing teaching methodologies, and providing appropriate support and training for faculty members to enhance maritime students' overall educational experience and outcomes. By identifying and addressing these factors, educational institutions can better support their student's academic journey and improve the quality of education provided in the maritime field. Furthermore, this study is supported by Yongxiang Li and Peirong Ge (2016) in their work on reforming basic math in maritime colleges. They stated that mathematics is an essential introductory course for college students majoring in Navigation, Thermodynamics, Mechanics, and mathematics so that students' knowledge structure can be expanded and provide services as a professional course of study. It is more important to cultivate the students' creative thinking, abstract, logical reasoning, learning ability, problem analysis, and problem-solving skills to uplift their comprehension.

2.3 Math Development Program in the Maritime Curriculum

Initially, the development model of applied mathematics learning materials based on Co-Prol for the cadets of the Nautical Study Program, Yogyakarta Maritime Academy, based on the analysis, can be summarized as follows: The developed learning materials met valid criteria and categorized as very good based on the results of material and media expert validation. The developed learning materials met practical criteria and were categorized as very good based on the results of cadets' evaluations, so it was suitable to be implemented in the learning process in the Applied Mathematics Course of Nautical Study Program, Yogyakarta Maritime Academy. The developed learning materials met the practical criteria for student learning outcomes with percentage completeness classically on the math test results. The developed learning materials have been proven to be successful in improving cadets' learning outcomes (Astriawati et al., 2019).

Moreover, an excellent maritime educational package would contain a selection of mathematics, computing skills, and basic knowledge of physics, engineering, or other professional input. The job title in the industry is very seldom that of a mathematician. It can be a researcher, a research engineer, a systems specialist, or a development manager. However, the reality is that the maritime industry is teamwork, just as industrial mathematics is teamwork. Success stories are born when a group of specialists can join their expertise and visions together in a synergic manner. Teamwork makes communication skills a necessary matter. It would be essential to train oneself and others to work in a project team where interpersonal communication is continuously present. To become a good, applied mathematician, one should be curious about other areas as well, to be interested and learn basic facts from a few neighboring areas outside mathematics (Akakpo, 2016).

In addition, maritime math courses that include basic mathematics content allow students to be more prepared for some courses in their field that require basic mathematical proficiency. Li and Ge (2016) also highlighted that the teaching strategy plays a significant role in this field. They stated that to enhance the mathematical proficiency of the cadets, a teacher shall explain numerous examples of how mathematical concepts are applied. Furthermore, Li and Ge (2016) identified various issues concerning mathematics teaching in maritime institutes. These issues encompassed several vital aspects, including the inadequacy of teaching content and the misalignment of math courses with other maritime subjects utilizing mathematical concepts. They also noted deficiencies in the theory of teaching content, a lack of innovative teaching approaches,

outdated teaching methods, and minimal student engagement during the learning process.

Additionally, they observed that examinations often focused on lower-order thinking skills, neglecting learning outcomes and leading to reduced student confidence in solving math-related problems. In response to these challenges, Li and Ge (2016) proposed reform measures for mathematics teaching in maritime colleges and universities. These included optimizing the curriculum structure to better align with professional needs, incorporating various teaching strategies, introducing mathematics elective courses and experimentation, enhancing teaching methods through innovation, and modifying examination types and approaches to encompass theory and practical applications. Consequently, Lyceum International Maritime Academy (LIMA), one of the colleges of Lyceum of the Philippines University - Batangas (LPU-B), introduces the Basic Gymathics as one of the enhancement programs in their maritime curriculum to develop the math proficiency and skills of their maritime students. According to Napicol (2018), Basic Gymathics is one of the essential foundations for maritime cadets to develop their problem-solving skills using basic mathematical concepts. It covers various areas of mathematics directly applicable to the maritime field, such as arithmetic, algebra, and solid mensuration.

Furthermore, Basic Gymathics has a twofold objective: firstly, to instill confidence in incoming maritime cadets when confronted with real-world problems intrinsic to maritime activities, and secondly, to equip them with the capacity to efficiently handle calculations, particularly in high-pressure, time-sensitive scenarios that necessitate rapid decision-making. Moreover, the course encompasses a structured progression through various mathematical domains, commencing with fundamental mathematical concepts to ensure cadets have a solid foundation. It further delves into the principles of arithmetic, emphasizing the significance of addition, subtraction, multiplication, and division in numerous maritime calculations.

Moving forward, the curriculum covers algebraic principles, enabling cadets to adeptly solve equations and work with variables, a skillset essential for multifaceted problem-solving scenarios. Additionally, the course explores solid mensuration, a crucial aspect of maritime mathematics, for measuring solid shapes, with applications in cargo capacity calculations and container volume assessments. The program seamlessly integrates these acquired mathematical skills into practical maritime scenarios, emphasizing the calculation of ship speed, pump flow rates, and fuel requirements, all of which are indispensable for ensuring the safety and efficiency of maritime operations. Throughout this educational journey, the course adopts a confidence-building approach, offering a multitude of practice sheets and individual activities to empower cadets and bolster their mathematical prowess. Furthermore, introducing time pressure within these activities compels cadets to perform calculations swiftly and accurately, emulating specific maritime situations' dynamic and fast-paced nature.

Overall, this course is well-tailored to meet the specific needs of maritime cadets, giving them a solid mathematical foundation and practical skills to handle calculations in their future careers. Building confidence through hands-on practice and exposure to time pressure can prepare them to face real-world challenges with competence and efficiency (Napicol, 2018).

2.4 Other Math development programs in maritime

In the maritime industry, many math development programs and initiatives are tailored to the unique demands of this specialized field. These programs have a common objective: to furnish maritime professionals with the advanced mathematical skills and knowledge essential for their roles aboard ships and within various maritime sectors. These initiatives go beyond the conventional classroom mathematics and delve into intricate mathematical concepts and their applications. Below are some examples of such math development programs that cater to different aspects of the maritime domain.

First, "Advanced Mathematics for Navigators" is a program designed to provide advanced mathematical training. It centers on complex mathematical concepts relevant to navigational calculations, encompassing celestial navigation, electronic navigation, and maritime chart plotting. The program equips officers and navigators with the proficiency to make precise mathematical decisions during their voyages, ensuring safe and

efficient maritime navigation.

Second, "Maritime Engineering Mathematics" targets marine engineers and engineering officers. It delves into advanced engineering mathematics, covering thermodynamics, fluid mechanics, electrical systems, and control theory. This curriculum empowers maritime engineers to analyze and address complex engineering challenges within vessels' intricate machinery and systems.

Third, "Maritime Finance and Accounting" may not be solely a math program. It is integral for maritime professionals in management and operational roles. This program involves mathematical calculations integral to financial analysis, budgeting, and cost control, equipping individuals in the maritime sector with the quantitative skills required for effective financial management.

Fourth, "Marine Surveying Mathematics" is essential for those involved in assessing the safety and integrity of vessels. Marine surveyors must precisely calculate vessel stability, cargo loading, hull integrity, and other safety-related measurements. This program equips them with the mathematical tools necessary to conduct accurate surveys and assessments, contributing to the safety of maritime operations.

Fifth, "Maritime Statistics and Data Analysis" is crucial in a data-driven world, particularly for maritime professionals who must deal with data related to vessel performance, weather patterns, cargo handling, and safety incidents. This program focuses on statistical analysis and data interpretation techniques, enabling professionals to make informed decisions by harnessing the power of data.

Sixth, "Maritime Operations Research" applies mathematical modeling and optimization techniques to maritime operations, facilitating the discovery of optimal route planning, scheduling, and resource allocation solutions. This is instrumental in ensuring the efficiency and effectiveness of maritime activities.

Seventh, "Maritime Risk Assessment and Management" is centered on using probability and statistics to assess risks related to maritime operations. By developing risk management strategies, this program enhances the safety and efficiency of maritime ventures.

Lastly, "Maritime Simulation and Modeling" employs mathematical techniques to replicate real-life maritime scenarios within a virtual environment. These aids maritime professionals in honing their decision-making skills without actual risk, contributing to safer and more efficient maritime operations.

These examples represent a fraction of the math development programs available within the maritime industry. The evolving landscape of maritime education is continually tailored to meet maritime professionals' specific needs, recognizing mathematics's pivotal role in ensuring maritime operations' safety, efficiency, and success. Furthermore, research has substantiated the effectiveness of enhancement courses as a vital component of the maritime curriculum. An extensive study conducted by the International Maritime Organization (IMO) has validated the efficacy of such enhancement courses in significantly improving students' mathematical skills across various areas, including problem-solving, reasoning, and spatial visualization. This research reinforces the value of incorporating these programs into the maritime education framework to enhance future maritime professionals' mathematical proficiency continually.

In addition, the study of Padernal (2023) uses mnemonics as a teaching strategy to improve maritime students' academic performance in solving the derivatives and integrals of various trigonometric functions. Mnemonic-aided instruction is an instructional strategy commonly used with students who have disabilities and those who are non-disabled. It was made to help you remember important facts. Mnemonic training makes it easier for students to acquire the general education curriculum by providing the tools to encode information better, making it much easier to recall afterward.

On the other hand, another study by the University of Southampton found that these enhancement courses improved students' performance in other maritime courses, such as navigation and seamanship. The study also

found that it was effective in reducing anxiety and stress levels in students, which can often be a barrier to learning. In order to ensure an increase in the quality of graduates, interventions need to be made in the domains of math training. For example, maritime education and training (MET) institutes, like the Australian Maritime College (AMC), provide seafarer training graduates with mandatory math training and optional math tutoring classes throughout their study period (Ghosh & Ruggunan, 2016).

3. Methods

Research Design - The quasi-experimental research design was used to evaluate the effectiveness of Basic Gymathics as a math development program for maritime students. In this design, the participants were not randomly assigned to groups, but the researchers used the pre-test and post-test examinations to measure their math skills. The student's math skills would be measured using a pre-test and post-test design before and after taking their Basic Gymathics course. The measures would include a standardized math test and performance assessment provided by the Gymathics Learning Center. This helps to control for some of the extraneous variables that could affect the study results. The pre-test and post-test design is one of the most frequently used quasi-experimental research designs in which a single group of research participants or subjects is pre-tested, given some treatment or independent variable manipulation, and then post-tested. Suppose the pre-test and post-test scores differ significantly. In that case, the difference may be attributed to the independent variable, but there is no control group because the research design is not strictly experimental (Colman, 2014). Furthermore, based on the study of Stratton (2019), quasi-experimental design has been a standard research method used for centuries. Pre-test and post-test design is a form of quasi-experimental research that allows for an uncomplicated assessment of an intervention applied to a group of study participants. For example, testing this new enhancement program by selecting a group of maritime students and first having them participate in a pre-test session based on the standardized math test and performance assessment provided by the Gymathics Learning Center, then having them complete the Basic Gymathics course, and then participating in a post-test session to evaluate the effectiveness of the course as a math development program for maritime students of LIMA. The Basic Gymnastics program was effective if post-test scores exceeded the pre-test.

Quasi-experimental research designs, like experimental designs, test causal hypotheses, according to White and Sabarwal (2014). The program (e.g., Basic Gymathics) was considered as an 'intervention' in both experimental and quasi-experimental designs, in which a treatment - comprised of the aspects of the program being evaluated - is examined for how effectively it fulfills its objectives, as measured by a pre-specified set of indicators. However, by definition, a quasi-experimental design lacks random assignment. Self-selection (in which participants pick therapy for themselves), administrator selection (e.g., by officials, teachers, lawmakers, and so on), or both approaches are used for condition assignment (treatment vs. no treatment or comparison), according to Padernal (2023).

Respondents of the Study - The study's respondents are first-year maritime students at Lyceum International Maritime Academy enrolled during the first semester of the 2020–2021 academic year. The total population of first-year maritime students at Lyceum International Maritime Academy is 358, of whom 263 were BSMT and 95 were BSMarE. The participants were selected by the researchers based on the following criteria: they had not yet taken Basic Gymathics; they were able to take the pre-test before the start of the semester; and lastly, they were able to take the post-test after the completion of the course. The researcher excluded the respondents with the following criteria: they had already completed the Basic Gymathics from the previous semester, could not take the pre-test before the start of the course, and did not complete the program. The researchers used the total sampling method, a purposive sampling technique that involves examining the entire population. Since the total population sampling method includes every member of the population of interest, researchers can gain profound insights into the topic they are studying. With such broad coverage of the population of interest, the chance of missing potential insights from omitted people is also lowered (Total Population Sampling | Lærd Dissertation, n.d.).

Data Gathering Instrument - The instrument used was the pretest and posttest provided and validated by the Gymathics Learning Center. Pre-tests and post-tests are common ways to measure the effectiveness of a program. By comparing the pre-test and post-test scores, researchers can understand how much students have learned or improved due to the program. It is crucial to make sure that the pre-test and post-test are equivalent. This means that the two tests should measure the same thing similarly. The researchers used both pretest and posttest, which are composed of 30 items from seven levels of the program. The following table below shows the distribution of the items in both tests:

Topic	Items
Level 1 – Fractions	4
Level 2 – Decimals and Percentages	3
Level 3 – Integers and Exponents	3
Level 4 – Radicals	4
Level 5 – Algebra 1	5
Level 6 – Algebra 2	4
Level 7 – Mensuration	7
Total	30

Data Gathering Procedure - The initial step of the researchers before conducting the data gathering was to check that none of the first-year maritime students had taken the course "Basic Gymathics" at their previous university or school with the help of the LIMA Registrar and Department. The researcher then asked for the pre-test and post-test exams provided and validated by the Gymathics Learning Center. At the beginning of the semester, before any topic was discussed, the students were given a pre-test to determine their current level of math proficiency before taking the program. Then, the researchers waited for all the respondents to complete their Basic Gymathics course for about 17 weeks of studying and training. The curriculum of “Basic Gymathics” consists of the following topics:

Level	Sub-Topics
Level 1 – Fractions	✧ Converting fractions ✧ Simplifying fractions ✧ Adding and subtracting similar and dissimilar fractions ✧ Multiplying and dividing fractions ✧ Fractions in word problem
Level 2 - Decimals and Percentages	✧ Converting fractions into decimals and percentages ✧ Finding percentages, rates, and bases in word problems
Level 3 - Integers and Exponents	✧ Solving word problems involving integers ✧ Exponents and scientific notation in word problems
Level 4 - Radicals	✧ Simplifying radicals ✧ Adding, subtracting and subtracting radicals ✧ Dividing and rationalizing radicals
Level 5 – Algebra 1	✧ Laws of exponents ✧ Exponential expressions ✧ Adding, subtracting and multiplying polynomials ✧ Factoring ✧ Simplifying rational expressions ✧ Multiplying and dividing rational expressions ✧ Adding and subtracting rational expressions
Level 6 - Algebra 2	✧ Linear and quadratic equations in one variable ✧ Interpolation and its application in maritime studies ✧ Formula transformation ✧ Variation
Level 7 - Mensuration	✧ Conversion of units ✧ Perimeter and circumference ✧ Area ✧ Volume

A post-test was then given at the end of the term to measure and determine how much students had learned or improved in math proficiency skills due to the program. The program was adequate if the post-test scores were significantly higher than the pre-test scores. Finally, with a 100 percent retrieval rate, the data have been collated, tabulated, interpreted, and analyzed by the statistician. Then, all information has been treated with care,

honesty, and the utmost confidentiality. The researchers collected all the inputs and data from the statistician for discussion and interpretation of the results, and then an action plan was proposed to enhance the program. The researchers reached a conclusion based on the objectives and results of the study, followed by recommendations for improvement in future studies related to this topic. The manuscript has been forwarded to the LIMA Research Coordinator for approval.

Data Analysis - Using different statistical tools, the collected data was utilized to present, analyze, and interpret the data gathered through tables, graphs, and charts. First, the frequency, percentage, mean, and standard deviation were used to identify students' mathematics performance in Basic Gymathics. Then, a paired sample t-test was used to determine the significant difference between the math skills of the maritime students using pre-test and post-test methods. The paired sample t-test, sometimes called the dependent sample t-test, is a statistical procedure used to determine whether the mean difference between two observations is zero. In a paired sample t-test, each subject or entity is measured twice, resulting in pairs of observations. The obtained data were also supported using SPSS version 26 to analyze the results further. Lastly, the equivalent percentage of the average scores of each class was determined in both pre-test (DT) and post-test (PT). These values were used to determine the improvement (in percent) in the student's test scores using the following formula:

$$\text{Improvement (\%)} = ((\text{PT Score-DT Score}) / (\text{DT Score})) \times 100$$

If the student's score in the Pre-test Test is "0", the DT score was changed to "1" to prevent errors in the automated calculation, i.e., mathematically speaking, a zero denominator is impossible. It is possible to have an improvement percentage greater than 100%. Statistically, this means that the student either (1) obtained a score that is twice the value of his DT score or (2) obtained a score that is more than twice the value of his DT score. Ranges in the improvement percentage were used to determine the students' improvement level. The following scale was therefore used:

Improvement (%)	Level of Improvement
0%	No Improvement
1% - 30%	Beginning
31% - 60%	Developing
61% - 90%	Accomplished
91% and above	Exemplary

Ethical Consideration - Ethical consideration for research projects is required because all researchers have moral and legal obligations. The researchers ensured that they communicated with the participants in a personal manner, that they did not violate their privacy without their permission, that the analysis did not negatively impact their feelings, and that all information obtained from them was acknowledged and accurately represented for this study. These were part of the research process to protect and preserve the rights of those who participated. The protocols were submitted to and approved by the Lyceum of the Philippines University – Batangas (Research Ethics Review Committee). The following ethical principles were observed in this research: The privacy of the participants is intended to be safeguarded. They were not obliged to provide their names or any identification that could be linked to them. This provided a pressure-free environment to allow the participants. Throughout the data collection and analysis phase, the anonymity of respondents was maintained. Reporting all the data honestly and without altering or manipulating the respondents' answers to satisfy specific predictions or interest groups was also guaranteed. With this, the researchers ensured that accurate and valid results were provided.

4. Result and Discussion

Table 1 below presents the distribution of the respondents grouped according to their mathematics performance. As can be gleaned from the table, out of 263 respondents, 89 of them, or 33.8 percent, obtained a grade of 1.25, which was classified as excellent performance, while 56 of them, or 21.3 percent, obtained a grade of 1.50, which was classified as superior. On the other hand, 44 respondents, or 16.7 percent, obtained a grade of

1.00, which was identified to show outstanding performance in mathematics.

Table 1

Distribution of BSMT Students Based on Final Grades in Basic Gymathics

Grade	Frequency	Percentage	Description
1.00	44	16.7	Outstanding
1.25	89	33.8	Excellent
1.50	56	21.3	Superior
1.75	35	13.3	Very Good
2.00	21	8.0	Good
2.25	7	2.7	Satisfactory
2.50	3	1.1	Fairly Satisfactory
2.75	2	0.8	Fair
3.00	6	2.3	Passing
Total	263	100	

Mean = 1.48 Standard Deviation = 0.43

In addition, 35 respondents, or 13.3 percent, who obtained a grade of 1.75 described having excellent performance. Meanwhile, there were 21 respondents, or 8 percent, who got a grade of 2.00, which was classified as good performance. Furthermore, seven respondents, or 2.7 percent, obtained a grade of 2.25, which is described as satisfactory performance. Six students, or 2.3 percent, got a grade of 3.00, which showed a passing performance. Lastly, three respondents, or 1.1 percent, who obtained a grade of 2.50, described themselves as having reasonably satisfactory performance, and two students, or 0.8, got a grade of 2.75, which was classified as fair performance. Therefore, the mean grade obtained from the final grades of the respondents in Basic Gymathics was 1.48 and the standard deviation was 0.43. Based on the findings, most BSMT students have superior performance in mathematics. This is an indication that the students have developed mathematical proficiency skills.

Consequently, in a study by Ali (2015), the connection between enhancement programs and the academic performance of college students in Zambia was explored. This investigation revealed a noteworthy and positive correlation between enhancement programs and mathematics academic achievement. Specifically, students who received high levels of enhancement programs demonstrated significantly superior academic performance compared to their peers who received lower levels of enhancement programs. This was determined by assessing their term examination grades. Furthermore, few known math enhancement programs in the Philippines aim to enhance the mathematical skills of younger students. As indicated in Agita's (2020) research, to overcome the obstacles in the learning process, it is essential to adopt mathematical learning models that actively involve students in the educational experience, thus providing them with more significant opportunities for engagement and participation. Engaging in an enhancement program has the potential to aid students in comprehending mathematics.

Table 2

Distribution of BSMarE Students Based on Final Grades in Basic Gymathics

Grade	Frequency	Percentage	Description
1.00	11	11.6	Outstanding
1.25	46	48.4	Excellent
1.50	20	21.1	Superior
1.75	13	13.7	Very Good
2.00	3	3.2	Good
2.25	1	1.1	Satisfactory
2.75	1	1.1	Fair
Total	95	100	

Mean = 1.39 Standard Deviation = 0.30

On the other hand, table 2 below presents the distribution of the respondents grouped according to their mathematics performance. It can be gleaned from the table that out of 95 respondents, 46, or 48.4 percent, obtained a grade of 1.25, which was classified as excellent performance. There were 20 respondents, or 21.1

percent, who obtained a grade of 1.50, which was identified to show superior performance in mathematics. However, 13 respondents, or 13.7 percent, who got a grade of 1.75 described having excellent performance. There were 11 respondents, or 11.6 percent, who obtained a grade of 1.00, which was classified as outstanding performance in mathematics. Furthermore, three students, or 3.2 percent, obtained a grade of 2.00, which is described as a good performance. There was one student, or 1.1 percent, who got a grade of 2.25, which showed satisfactory performance, and also one student, or 1.1 percent, who obtained a grade of 2.75, described to have fair performance in mathematics.

To sum up, the mean grade from the final grades of the respondents in Basic Gymathics was 1.39, and the standard deviation was 0.30. Based on the results, most BSMarE students have superior performance in mathematics. This is an indication that the students have developed mathematical proficiency skills. In addition, the research conducted by Oluwole and Olanrewaju (2016) states that an enhancement program is a highly effective strategy for improving mathematics learning outcomes in school-going adolescents. The study highlights an enhancement program's noteworthy and beneficial impact on improving math learning outcomes, emphasizing the immediate necessity of consistently applying it to tackle the long-standing problem of substandard learning results. Moreover, according to Agita's (2020) research findings, students enrolled in the Kumon learning program, one of the math enhancement programs for young students in the Philippines, improve their ability to identify problems, plan problems, solve problems, and interpret solutions. These enhancement programs, like Gymathics, Kumon, etc., are highly beneficial for students in marine engineering programs, mainly due to the substantial mathematical problems that this field entails.

Table 3

Paired Sample t-test Results for BSMT and BSMarE in Basic Gymathics

Test Form	Mean Score	t-test	p-value	Interpretation
BSMT Students				
Pretest	15.54	-27.880	0.000	Significant
Posttest	26.28			
BSMarE Students				
Pretest	17.31	-21.088	0.000	Significant
Posttest	27.97			

Table 3 shows the Paired Sample t-test for BSMT and BSMarE in Basic Gymathics. It can be gleaned from the table that the pre-test to post-test increases in average scores for BSMT and BSMarE. At a 0.05 significance level, the null hypothesis is rejected. Thus, it can be concluded that there is a significant difference between the mean score of the pre-test and post-test for BSMT and BSMarE. The findings show that the course has significantly improved the students' math test scores. At the end of the course, the students have gained more confidence in solving word problems involving fractions, decimals, and percentages; simplifying algebraic and rational expressions; transforming equations to find unknown values; and calculating the perimeter, area, and volume of particular objects and applying these to various work-related calculations. Hence, it is strongly evident that basic gymathics can develop the students' mathematical proficiency skills.

Haslenda Yusop et al. (2015) used pre-tests and post-tests to determine the effectiveness of educational camps in improving students' understanding of mathematics. They concluded that there is a statistically significant difference between the mean mark of the pre and post-tests for each chapter. Thus, the statistical analysis may prove that education camps effectively strengthen students' understanding of mathematics. Furthermore, according to Stratton (2019), establishing a definitive research direction is a key advantage in utilizing a pre-test and post-test study design. This approach systematically evaluates a dependent variable, such as knowledge or attitude, before and after introducing an independent variable, such as training or an information presentation session. Even though probability statistics like t-test analysis might indicate statistical significance, it is equally important to consider the overlap of the ranges in measures of central tendency (confidence intervals or quartiles) for mean or median values. This overlap can indicate a lack of clinical significance and limited practical relevance for research findings.

Table 4 below shows the results of the pre-tests and post-tests and the improvement in the test scores in each class. Students who could not complete the program were excluded from the data, i.e., students who officially and unofficially dropped during the semester). The average values were taken for each program (BSMT and BSMARE), and the general average was taken to reflect the overall performance of all the students who took the program.

Table 4

Level of improvement using paired results of Pre-test and Post-test

No.	Section	pre-test (30 pts)		post-test (30 pts)		Improvement(%)	Level of improvement
		score	%	score	%		
1	BSMARE JI-A1	16.44	54.81	27.09	90.30	86.2	Accomplished
2	BSMARE JI-A	18.08	60.27	28.75	95.83	68.5	Accomplished
3	BSMT JI-A1	17.94	59.81	26.61	88.69	60.9	Developing
4	BSMT JI-A	16.62	55.39	25.47	84.91	65.4	Accomplished
5	BSMT JI-B	15.63	52.10	26.44	88.15	94.4	Exemplary
6	BSMT JI-C	14.66	48.87	25.45	84.82	106.5	Exemplary
7	BSMT JI-D	12.88	42.92	27.07	90.24	132.1	Exemplary
AVERAGE		16.04	53.45	26.70	88.99	87.70	Accomplished

From the data, the improvement in the test scores of maritime students ranges from 60.9% (BSMT JI-A1) to 132.1% (BSMT JI-D). BSMT JI-A1 had the lowest improvement percentage since the average DT score for the class is higher than those of other sections, next to BSMARE JI-A. Among the seven classes, the DT score of BSMARE JI-A indicates that students from this section have a higher level of math proficiency than students from other sections. All sections showed more than 60% improvement in their test scores. BSMT JI-C and BSMT JI- D showed more than 100% improvements since the students' pre-test scores were lower than those of other sections. The data shows that the class averages range from 25 to 27 in the post-test compared to 12 to 17 in the pre-test. It could be inferred that at the end of the program, even struggling students can achieve almost the same level of math proficiency as those already confident with their math skills.

On the other hand, in pre-test results, most students could answer the examination within the standard limit with an average completion time of 45.63 minutes. The students easily answered test items on fractions, decimals, and integers. The average scores for the classes range from 12.96 to 17.94. In general, most students were able to answer 53.27% of the examination correctly. From the examination, most of the students, about 70% to 90%, have answered the following items correctly: (1) Converting fractions to decimals, (2) Converting fractions to percent, (3) Adding dissimilar fractions, (4) Multiplying fractions, (5) Finding the percentage in a word problem, and (6) Simplifying radicals. Hence, it can be inferred that most students understand the concepts and mathematical operations involving fractions, decimals, percentages, and radicals. From the examination, only a few students, about 20% to 50%, were able to answer the following items correctly: (1) Word problem involving fractions, (2) Word problems involving the use of integers, (3) Simplifying rational expressions, (4) Word problems on linear equations, (5) Word problems involving the conversion of units, (6) Word problems on circumference and perimeter, (7) Word problems on volume, and (8) Word problems in the area.

Consequently, it can be inferred that most students encounter difficulties in solving word problems, which could be mainly attributed to the student's level of reading comprehension. Most of them are familiar with the mathematical concepts involved. For instance, they may know how to compute the perimeter, volume, and area if the given were already made evident. However, they find it difficult to "extract" or "derive" the given from the word problem and determine what should be computed in the problem. The findings show that the program has significantly improved the students' math test scores. At the end of the program, the students have gained more confidence in solving word problems involving fractions, decimals, and percentages; simplifying algebraic and rational expressions; transforming equations to find unknown values; and calculating the perimeter, area, and volume of particular objects and applying these to various work-related calculations.

On the other hand, Adao et al. (2015) noted that a considerable proportion of students dealing with math anxiety typically lack self-assurance in their mathematical aptitude. Consequently, they often take only the minimal required mathematics courses, significantly limiting their career options. To address this issue, students need to bolster their confidence, and one way to achieve this is by implementing enhancement programs like Basic Gymathics, which can help them gain more confidence in solving word problems related to fractions, decimals, and percentages. Moreover, in line with the research by Descargar and Cardona (2016), their findings emphasize the necessity of examining mathematics study habits from a multidimensional perspective. An effective enhancement program should engage a broad spectrum of education stakeholders, encompassing teachers, students, parents, and the community. Hence, it is paramount to meticulously adapt the Gymathics enhancement program to align closely with the specific curriculum. For example, in maritime education, it is beneficial to integrate aspects associated with ships, such as navigation and onboard vessel operations, into the program framework.

5. Proposed Action Plan

Based on the result of the study, there are still a few maritime students who got fair or passing grades in their Final Grades and low post-test exam scores. The researchers propose a precise action plan for further enhancement of the Basic Gymnastics program. Below is the list of the following action plans:

Develop a Basic Gymathics curriculum tailored to maritime students' needs - The Basic Gymathics curriculum should be designed to develop the skills and abilities of maritime students. For example, introducing educational games as a learning medium. Jatmiko (2021) concluded from his studies that developing maritime-themed educational games as learning media for mathematics in high school students on the system of linear equations in three variables met valid, practical, and effective criteria. This kind of learning experience can entice more maritime students to study and improve their skills in mathematics.

Train Instructors in Basic Gymathics - Training the instructor is an important step in implementing a Basic Gymathics program. The instructors should be familiar with the curriculum and be able to deliver the activities to students effectively. The training should be conducted by qualified instructors with experience teaching Basic Gymathics. The training should be interactive and engaging and provide the instructors with the skills and knowledge they need to succeed.

Implement the Basic Gymathics program in maritime schools - The program should be implemented as a supplement to the regular math curriculum. This means the program should be offered in addition to students' regular math classes. The program could be offered as an elective course or integrated into the regular math curriculum. There are a few things to consider when implementing the Basic Gymathics program in maritime schools. It is important to ensure that the program is aligned with the goals of the maritime curriculum. The program should be designed to help students develop spatial reasoning, problem-solving, and confidence in math to succeed in maritime careers.

6. Conclusion

The majority of the BSMT and BSMarE have excellent performance in Basic Gymnastics. There was a statistically significant difference between the pre-test and post-test as an indication of the improvement of the mathematical proficiency and skills of the maritime students. Effectiveness of Basic Gymathics is evident in the substantial improvement in the mathematical performance of maritime students in the areas of basic mathematics, algebra, and solid mensuration. The researchers proposed an action plan to enhance the Basic Gymathics program further.

6.1 Recommendation

Maritime Higher Education Institutions (MHEIs) may develop the Basic Gymathics course into a much

more interactive and enjoyable learning experience program to entice more maritime students to study and improve their skills in mathematics. Given the significant improvement in mean scores following the pre-test and post-test comparison, it is advisable to incorporate regular assessments and comparisons of pre-test and post-test results in other courses to help ensure ongoing academic progress. In light of Basic Gymathics proven effectiveness in enhancing mathematical proficiency, it is recommended to develop tailored modules that address specific maritime-related mathematical problems, ensuring comprehensive preparation for students' future careers. Based on the results of this study, the researchers propose the implementation of Basic Gymathics in every maritime school and its expansion across various academic disciplines. The program is valuable for helping students improve their mathematical proficiency and skills. Maritime Higher Education Institutions (MHEIs) should promote collaborative research and the sharing of best practices among maritime schools to optimize the effectiveness of basic gymathics across diverse academic disciplines.

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