

## Development of a Supplemental Learning Material in Mathematics for Seamanship (Trim and Stability)

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**ABSTRACT:** This developmental research aimed to produce a supplemental learning material in Mathematics for Seamanship (Trim and Stability) using the ADDIE model. Mathematics concepts were determined through content analysis by examining the Seamanship Instructor's Guide and class handouts and validated by two maritime teachers of JBLFMU-Arevalo. An outline of the lessons was drafted from the results of the content analysis. The supplemental learning material was then developed using the 4E Instructional model – Engage, Explore, Explain, and Evaluate. Furthermore, simple random sampling was used to select the 30 BSMT 2 students taking up Seamanship during the second semester of school year 2018-2019 as respondents. Meanwhile, a purposive sampling was used to determine 18 experts – 12 in Maritime Education and 6 in Mathematics. A researcher-made questionnaire that underwent validation and reliability testing was utilized to gather data. The statistical tools used were frequency, mean, and standard deviation. The results of the study showed that the mathematics concepts embedded in Seamanship lessons were: (1) Integers, (2) Fractions, (3) Decimals, (4) Percent, (5) Algebra, and (6) Trigonometry. It was also found that students have a "Very High" satisfaction towards the supplemental material when taken as a whole and in terms of physical aspects, objectives, learning activities, evaluation procedure, and usefulness. On the other hand, experts believed the supplemental learning material has a "Very High" acceptability when taken as a whole and in terms of physical aspects, objectives, and usefulness. However, experts found that it only has a "High" acceptability in terms of learning activities, and evaluation procedure. Thus, the supplemental learning material in Seamanship is appropriate, relevant, and useful in general and in terms physical aspects, objectives, learning activities, and evaluation procedure. It has also met the expectations and standards of chosen experts as reflected on their evaluation rating. Furthermore, the supplemental learning material may be subjected to the scrutiny of experts in the production of instructional materials and may be edited, if the expert suggests to do so. The university may use this supplemental learning material in improving students' mastery of important mathematics lessons needed in Seamanship. Similarly, future researchers may conduct an experimental study to determine if the use of this supplemental learning material may improve students' academic performance in Seamanship or another developmental research to produce similar supplemental learning materials for other maritime and general education subjects.

### 1 INTRODUCTION

For more than two millenniums, mathematics has been a part of the human search for understanding.

Mathematical discoveries and breakthroughs attempt to reveal the natural world and arrive to the truth using careful reasoning (Lewis, 2008).

Mathematics serves as an instrument in the development of other sciences and has been applied to various aspects of the human world [1, 2, 3]. It is utilized in technology, art, educational assessment, and even in navigation. In the 17th and 18th centuries, the leading scientific question, perhaps, was how to find out exactly where you are at sea [4].

Mathematics is important in navigation [5]. Mathematics, an exact science, has advanced for thousands of years throughout history. Maritime activities, which are almost as old, transport passengers and goods from one location to another conveniently and economically. Though the link between the two is not reciprocal, it is undeniable that without the application of mathematical models, maritime affairs, as we know them today, would not exist [6].

One of the most important things that one should know in navigation is about a ship's trim and stability. One must have a basic understanding of trigonometry and the functions of right triangles to comprehend the principles of ship stability fully. There are also certain principles of physics needed in order to have sufficient understanding of stability. One should be familiar with terms such as volume, density, weight, center of gravity, force, and moments. [7].

Seamanship (SEAM) 2B, a professional subject in the BSMT Program is mostly centered on Trim and Stability. It covers the advanced competencies for monitoring the loading, stowage, securing, and care during voyage and the unloading of cargoes. In addition, students are also taught how to maintain the seaworthiness of the ship and the control of trim, stability, and stress of the ship [8].

Meanwhile, Mathematics is considered a difficult subject by most of the students. However, it is a fundamental part of school curriculum [1]. In this case, it is an essential tool in the subject, SEAM 2B. It is therefore, a must for students to master certain mathematical concepts and skills. Thus, this research study is conducted.

This developmental research aimed to produce a supplemental learning material for SEAM 2B.

## 2 MATERIALS AND METHODS

### 2.1 Research Design

This study employed a developmental research design specifically, instructional material (IM) design. Richey and Klein [9] labeled it as an approach where new procedures, techniques, and tools are created based upon a systematic analysis of specific cases. This study particularly fell under the Type 1 developmental research since it focused on the production of an instructional material.

To develop the supplemental learning material, this study followed the ADDIE Model. It stands for Analysis, Design, Development, Implementation, and Evaluation.

### 2.2 Respondents

The respondents of this study were 30 BSMT students taking SEAM 2B (Trim and Stability) that were selected through simple random sampling. They were asked to determine their satisfaction towards the supplemental learning material.

Meanwhile, six experts in the field of Mathematics, and 12 experts in the field of maritime education were chosen through purposive sampling. They determined the acceptability of the supplemental learning material.

Table 1 shows the distribution of the respondents.

Table 1. Distribution of Respondents (N=48)

Category	f	%
Students	30	100
Experts	18	100
Mathematics	6	33
Maritime Education	12	67

### 2.3 Instrument

The instruments used in the study were the matrix for content analysis, students' satisfaction survey form, and experts' evaluation form. These were validated by three teachers who have an expertise in research and grammar. Furthermore, the students' satisfaction survey form and experts' evaluation form were reliability-tested using Cronbach alpha. The reliability test showed that the instrument is 0.98 or 98% reliable.

### 2.4 Data Collection

Based on the ADDIE Model [10], the data gathering procedure can be best illustrated in Figure 1.

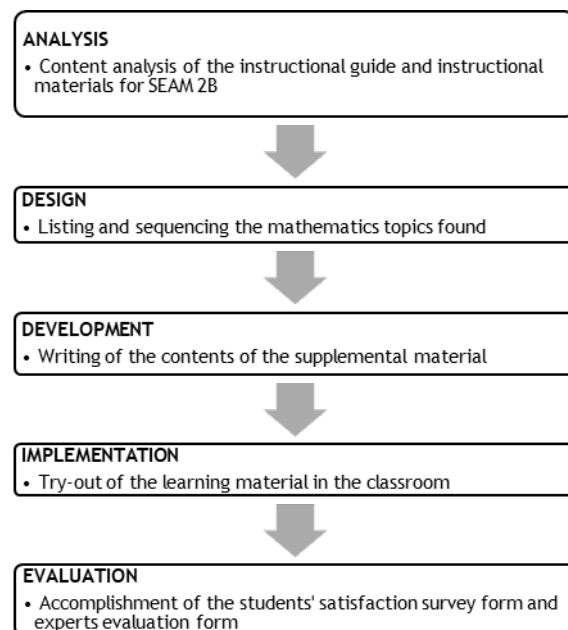


Figure 1.

In the Analysis phase, the researchers looked through the instructional guide and instructional materials for SEAM 2B (Trim and Stability) using content analysis to determine mathematics concepts

embedded in the lessons. These topics were included in the supplemental learning material.

In the Design phase, the researchers consulted maritime teachers to review the outline/list of mathematics concepts for the supplemental learning material. This was done through an informal interview. They suggested other mathematics topics that the researcher has not included.

In the Development phase, exercises and problems were written. These were validated by both a mathematics and a professional teacher. The material was patterned with the 4E Instructional model. 4E stands for Engage, Explore, Explain, and Evaluate [11]. In the Engage stage, the student's interest was involved and the topic was connected on a personal level. This phase of the learning cycle helps students answer questions such as: Why is this topic important to me? In the Explore stage, students reinforce their understanding of concepts, apply the concepts, and practice the process through learning activities. In this learning phase, students begin to construct for themselves the meaning from the exploration activities. In the Explain stage, students read the text chapter, which develops a context for important concepts. This strengthens the students' personal understanding of key concepts they have generated in the Engage and Explore phases. The Explain phase is supported by step-by-step computation examples which contain discussions so that students can study independently. It also contains practice items for formative assessment. In Evaluation stage, students find self-assessment which has been based on the Engage, Explore, and Explain phases. These quizzes may contain computation and problem-solving items depending on the objectives of the lesson.

In the Implementation phase, the supplemental learning material was given to students for their perusal. A copy of the supplemental learning material was provided to each student so that they can fully go through the material.

In the Evaluation phase, the supplemental learning material was evaluated by both the students and the experts. In addition, their satisfaction and acceptability level were determined at this phase.

### 2.5 Data Analysis

Both qualitative and quantitative techniques were used in the conduct of this study.

The qualitative analysis technique employed the content analysis. It was used to determine the mathematics concepts embedded in the SEAM 2B lessons.

Meanwhile, frequency, mean, and standard deviation were the statistical tools utilized.

Frequency was used to determine the number of respondents in the study.

Mean was used to determine the acceptability of the developed supplemental learning material in SEAM 2B (Trim and Stability) through the students' satisfaction and experts' evaluation rating.

The mean scale, description, and indicators for satisfaction and acceptability in the supplemental learning material in Mathematics for SEAM 2B (Trim and Stability) are found in Table 2.

Table 2 Levels of Satisfaction and Acceptability in the Supplemental Learning Material

Mean Scale	Description	Indicators Satisfaction	Acceptability
3.51-4.00	Very High	Students find the overall appearance and content of the supplemental learning material excellent. They find it very useful in the subject.	Experts think that the overall aspects of the supplemental learning material are excellent and have minimal revisions.
2.51-3.50	High	Students find most parts and content of the supplemental learning material sufficient. They find it somehow useful in the subject.	Experts think that the overall aspects of the supplemental learning material are very good but still have several revisions.
1.51-2.50	Low	Students find most parts and content of the supplemental learning material insufficient.	Experts think that the overall aspects of the supplemental learning material are good but need a lot of revisions.
1.00-1.50	Very Low	Students find the overall appearance and content of the supplemental learning material not usable.	Experts think that the overall aspects of the supplemental learning material should all be revised or scrapped.

Standard deviation was used to determine the spread of the responses that were obtained in the students' satisfaction and experts' evaluation.

## 3 RESULTS AND DISCUSSION

To create the supplemental learning material, various Mathematics topics were determined based on the SEAM 2B (Trim and Stability) lessons. Table 3 presents the Mathematics lessons found in SEAM 2B (Trim and Stability) lessons. These are: (1) Integers, (2) Fractions, (3) Decimals, (4) Percent, (5) Algebra, and (6) Trigonometry.

These concepts support the claim of Gafoor and Kurukkan [1] that mathematics is a fundamental part of school curriculum and an essential tool in the subject. Moreover, the results are also aligned to the claim of Stanivuk et al. [6] that there is a link between mathematics and maritime affairs.

Furthermore, specific competencies in the mathematics lessons were identified. These competencies are found in the Mathematics Framework for Philippine Basic Education [12]. These can be best illustrated in Figure 2.

Table 3 Mathematics Concepts Embedded in Seamanship 2B (Trim and Stability) Lessons

Seamanship Lessons	Mathematics Lessons
1. Stability	Integers, Decimals, Fractions, Algebra, Trigonometry
2. Cargo Calculations and Cargo Plans	Integers, Decimals, Fractions, Algebra
3. Stress tables and stress calculating equipment	Algebra (Graphs)
4. Draught, Trim, and Stability	Integers, Decimals, Algebra
5. Approximate Calculations of Areas and Volume	Integers, Decimals, Algebra
6. Effects of Density	Integers, Decimals, Algebra
7. Stability at Moderate and Large Angles of Heel	Integers, Decimals, Algebra, Trigonometry
8. Dynamical Stability	Integers, Decimals, Percent, Algebra
9. Approximate GM by Means of Rolling Period Test	Integers, Decimals, Algebra, Trigonometry
10. Intact Stability Requirements for Carriage of Grain	Integers, Decimals, Algebra
11. Effect on trim and stability of a ship in the event of damage to and consequent flooding of a compartment and countermeasure to be taken	Integers, Decimals, Percent, Algebra
12. Calculation of Vessel Condition after Flooding	Integers, Decimals, Percent, Fractions, Algebra
13. Effect of Flooding on Trim	Integers, Decimals, Algebra

Table 4. Students' Satisfaction Towards the Supplemental Material in Seamanship 2B (Trim and Stability)

Category	n	Mean	Description	SD
Overall	30	3.66	Very High	0.62
Physical Aspect	30	3.71	Very High	0.63
Objectives	30	3.64	Very High	0.62
Learning Activities	30	3.62	Very High	0.68
Evaluation Procedure	30	3.66	Very High	0.64
Usefulness	30	3.67	Very High	0.63

Note. 3.51-4.00=Very High Satisfaction; 2.51-3.50=High Satisfaction; 1.51-2.50=Low Satisfaction; and 1.00-1.50=Very Low Satisfaction.

The results show that in general, students have a "Very High" satisfaction (M=3.66, SD=0.62) towards the supplemental learning material. In addition, they also have a "Very High" satisfaction in terms of physical aspects (M=3.71, SD=0.63), objectives (M=3.64, SD=0.62), learning activities (M=3.62, SD=0.68), evaluation procedure (M=3.66, SD=0.64), and usefulness (M=3.67, SD=0.63).

The findings of this study support the notion that learning satisfaction is the effect of the processes which have taken place during the students' learning process. Additionally, satisfaction can also be regarded as relative outcomes between expectation and perceived service either with pleasure or with displeasure [13]. In addition, the quality of learning materials affects the satisfaction of the learners. The more confidence and trust the learners have in the quality of materials used for their learning, the more satisfied they are [14]. Therefore, one can say that students' expectations of the supplemental learning material have been met, thus resulting to a "Very High" satisfaction. Meanwhile, Table 5 presents the experts' acceptability of the supplemental learning material in SEAM 2B in general and in terms of physical aspects, objectives, learning activities, evaluation procedure, and usefulness. Data were based on the responses of experts in maritime education and in mathematics.

Table 5 Acceptability of the Supplemental Learning Material in SEAM 2B (Trim and Stability) According to Experts

Category	n	Mean	Description	SD
Overall	18	3.52	Very High	0.52
Physical Aspect	18	3.51	Very High	0.43
Objectives	18	3.55	Very High	0.54
Learning Activities	18	3.50	High	0.51
Evaluation Procedure	18	3.45	High	0.59
Usefulness	18	3.57	Very High	0.66

Note. 3.51-4.00=Very High Acceptability; 2.51-3.50=High Acceptability; 1.51-2.50=Low Acceptability; and 1.00-1.50=Very Low Acceptability.

The results show that in general, experts deem that the supplemental learning material has a "Very High" acceptability (M=3.52, SD=0.52). Moreover, it also has a "Very High" acceptability in terms of physical aspects (M=3.51, SD=0.43), objectives (M=3.55, SD=0.54), and usefulness (M=3.57, SD=0.66). On the other hand, it has a "High" acceptability in terms of learning activities (M=3.50, SD=0.51) and evaluation procedure (M=3.45, SD=0.59).

The findings show that the supplemental learning material has exceeded the standards of the chosen experts in terms of the physical aspects, objectives,

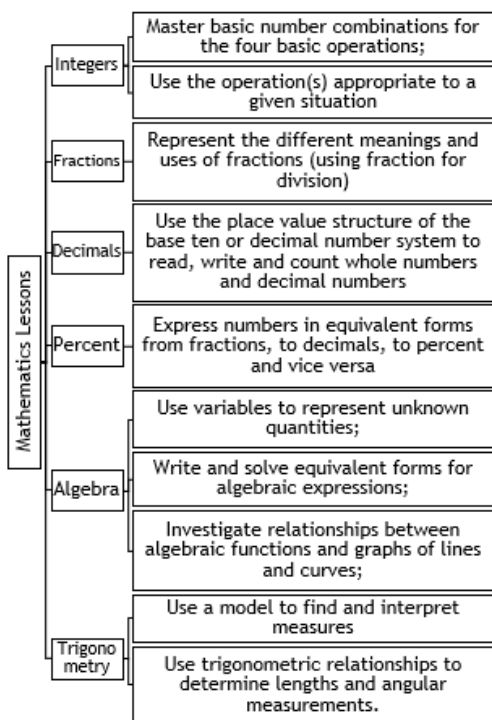


Figure 2.

Meanwhile, Table 4 shows the mean satisfaction of students towards the developed supplemental learning in SEAM 2B in general and in terms of physical aspects, objectives, learning activities, evaluation procedure, and usefulness.

and usefulness and has met their expectations in terms of learning activities and evaluation procedure. The findings of this study is similar to that of Gayagay [15] and Menor and Limjap [16].

#### 4 CONCLUSIONS

Based on the findings, it is clear that various mathematics lessons were imbedded in the SEAM 2B (Trim and Stability) lessons. One way to strengthen learning in Seamanship 2B may be done by helping students master these mathematics lessons. Secondly, the supplemental learning material in SEAM 2B is appropriate, relevant, and useful in general and in terms physical aspects, objectives, learning activities, and evaluation procedure as shown by the students' satisfaction rating and has met the expectations and standards of chosen experts as reflected on their evaluation rating.

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