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Course Performance of Marine Transportation in Celestial Navigation (NAV4 233L3) Using Mathematical Processes: Basis for Course Enhancement

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Abstract

The study determined the course performance of the 2nd Year Bachelor of Science in Marine Transportation students of Asian Institute of Maritime Studies enrolled during the 3rd Trimester of School Year 2021-2022 in Celestial Navigation (NAV4 233L3) course. To know the course performance, mathematical processes was evaluated by answering a self-assessment questionnaire. The content of the survey was inspired by the mathematical framework created by of the Department of Science and Technology with the Philippine Council of Mathematics Teacher Education, Inc. .The mathematical processes assessed in the study were: Problem Solving Skills, Communicating Mathematically, Math Reasoning and Making Math Connections.

There were 173 samples taken using Slovin's formula with 5% level of significance. Embedded mixed method was applied to conduct the study. The grades of the respondents in NAV 3 and NAV4 233L3 is being correlated to find if the grades have significant relationship using Pearson correlation by running SPSS version 29. It yielded that the grades in NAV 3 and NAV4 233L3 has positive weak correlation, $r=.244$, $p<.001$. Thus, there is a significant relationship between the two grades, therefore, the null hypothesis was rejected. The mean of the course performances applying math processes was compared when grouped according to the profile of the respondents. The Analysis of Variance was the statistical treatment applied utilizing SPSS. There is no significant differences with the means of the course performances applying mathematical processes when grouped according to age, gender and Senior High School strand because the p value are all greater than .05 so null hypothesis was accepted.

Under the thematic qualitative method, the sharing of interests and of difficulties of the respondents were analyzed. The answers under the interests of the respondents were grouped into three themes: Problem Solving is interesting; NAV4 233L3 has interesting topic/s; and Interesting Laboratory Activities: Using Nautical Almanac, Marine Sextant and Sight Reduction Table. On the other hand, the difficulties the respondents had when studying NAV 4 233L3 was also summarized into three themes: NAV4 233L3 is not difficult: the Instructors discussed the topics well; Crucial in NAV4 233L3:Problem Solving; and NAV4 233L3 Mathematics Connections is Hard: Plotting, Completing Tables and Math Equations.

Keywords: Celestial Navigation (NAV4 233L3), Mathematical Processes, Course Performance, Self-Assessment

1. Introduction

The maritime industry in the Philippines greatly helps in connecting commerce and industry globally resulting to the continuous attainment of the growth and economic progress of the society. The Maritime Industry Authority (MARINA) is the agency responsible for the development, promotion and regulation of the maritime industry in the Philippines. MARINA is under the Department of Transportation (DOTC) and was established on March 13, 2014 under Republic Act 10365, as the single maritime administration that implements and enforces the 1978 International Convention on Standards of Training, Certification and Watch-keeping (STCW) for seafarers, as amended, and as an international agreement.

Under the minimum competencies of Bachelor of Science in Marine Transportation (BS MT) as mandated by the joint CHED-MARINA memorandum (circular no. 01, series of 2019), the program outcome is to perform navigational watch at the operational level, and the performance indicators are to plan and to conduct a passage, and to determine position including the affirmation of safe navigational watch. Similarly, part of the professional courses of the program focus on the navigation content. NAV4 233L3 is the course code of Celestial Navigation subject in AIMS (Asian Institute of Maritime Studies) conducted in 7.5 hours every week (3 hours lecture and 4.5 hours laboratory) equivalent to 3 units in one trimester, as mandated by CHED (2017). A maritime student could take the subject if he passed the 3 prior subjects: Navigational Instruments with Compasses (NAV 1), Terrestrial and Coastal Navigation 1 (NAV 2) and Terrestrial and Coastal Navigation 2 (NAV 3). Terrestrial and Coastal Navigation 2 (NAV 3) is a 5unit course prerequisite to NAV 4.

Celestial Navigation promotes critical thinking. It will be an intellectual challenge for maritime students finding one's geographical position by means of astronomical observations, requiring knowledge, judgement and mastery. Solving practical problems in Celestial Navigation may need mathematical processes and practices which were inculcated to the students during their grade and high school years. Effective teachers engaged students in meaningful learning to promote their ability to make sense of mathematical ideas, and reason mathematically (Dixon,2018).

The researchers wanted to find out if AIMS BS Marine Transportation (BSMT) students are capable enough to be skillful navigators especially in utilizing celestial navigation onboard in the future.. To know their proficiency, mathematical processes be evaluated by answering a self-assessment questionnaire.

Statement of the Problem. The study, Course Performance of Marine Transportation Students in Celestial Navigation (NAV4 233L3) Using Mathematical Processes: Basis for Course Enhancement, aims in general to determine the course performance of the 2nd Year Bachelor of Science in Marine Transportation (BSMT) students of AIMS who were enrolled during the 3rd Trimester of school year 2021-2022 in Celestial Navigation (NAV4 233L3) course. After determining the course performance, enhancement of NAV4 233L3 is indicated in this study to improve mathematical processes or skills of the students that needed more attention.

2. Literature Review

The Celestial Navigation. European and American sailors and navigators were familiar with both plane and spherical geometry. They believe that ships sail not on a plane, but upon the surface of a sphere. All sides of spherical triangles are arcs of great circles, but a ship can not sail along a great circle unless it is constantly changing its heading and direction of travel. Vessels under sail, left to their own devices, travel

at a constant angle to the wind. The helmsman (a person who steers the ship) makes small corrections via his control of the rudder to sail at a constant compass heading – which approximates a constant direction. The bearing of a vessel is defined by the angle the vessel's center line makes with a meridian (a great circle which passes through the North and South poles.) If the vessel is heading due North or due South, he will travel along a meridian of longitude (a great circle.) If the vessel is heading due East or due West, he will travel along a parallel of latitude (a small circle.) But a vessel on any other point of sail will travel along a "loxodromic spiral," which may circle the earth many times, coming ever closer to one of the poles. (Loxodromic spiral refers to rhumb lines or to map projections on which rhumb lines appear straight, as on a Mercator projection (Collins Dictionary,2022). All such paths approach either the North or the South pole (Silverberg, 2005). A Mercator projection is a projection widely used for navigation charts, because any straight line on a Mercator projection map is a line of constant true bearing that enables a navigator to plot a straight-line course.

Effect of the Use of Celestial Navigation Technology in Marine Navigation. As with the realization of the limitations of the earlier technology, advancements have provided solutions to provide more effective information for marine navigation. Though technology may have provided the solutions for the limitations encountered, technology is in itself still limited to address certain emergencies and threats. Thus, learning of the crude method of celestial navigation is recommended. Although this realization has been supported by the revival of the course of celestial navigation in the US Naval Academy, the need to reinforce the significance of using crude celestial navigation methods must be made (Alshanin, 2017).

In a research conducted by Ibanez (2018) of the University of Basque Country, Portugalete, Spain entitled, "Teaching Celestial Navigation in the Age of GNSS (Global Navigation Satellite Systems)", he mentioned that the International Maritime Organization (IMO) Subcommittees on Standards of Training and Watchkeeping (STW) on March 2008 deliberated a proposal made by Norway that is to remove the requirements of Celestial Navigation from Chapter II of the STCW Code (IMO STW, 2008a). In November 2008, China suggested on some of the proposal amendments in Chapter II of the STCW Code, that is, to maintain the mandatory requirement on knowledge and skills with respect to Celestial Navigation restricted to the sun and stars' observations, and to determine ships position, while improving the method for celestial navigation calculations (electronic nautical almanac and celestial navigation calculation software) (IMO STW, 2008b). Then in the 2010 Manila Amendments to the STCW Code maintained the ability to use celestial bodies to determine the ship's position as a fundamental part of competency; that is, to plan and conduct a passage and determine position, for ocean-going navigation. In accordance with the STCW Code (IMO, 2011), among other skills and abilities, an officer on navigational watch should have the "ability to use celestial bodies to determine the ship's position and compass errors", in order to ensure safe passage. Celestial navigation may be omitted for the issue of restricted certificates for service on near-coastal voyages, but primarily used as a back-up to satellite systems in oceanic navigation.

On the other hand, to be skilful in celestial navigation, a student should already develop his mathematical abilities since if you will overview the curriculum guide of Celestial Navigation NAV4 233L3, application of conversion of units in degrees and minutes, locating positions, use of table of values, problem solving, finding solutions, interpreting data, reasoning on how to get the true position, and connecting previous

concept to other situations are just few of the mathematical skills to be observed when enrolled in NAV4 233L3. According to the National Council of Teachers of Mathematics (NCTM, 2000) the purpose of learning mathematics is to develop mathematical abilities which include problem-solving ability, reasoning ability, communication ability, ability to make connections, and representation ability.

Mathematical Thinking Processes. Toni Scusa of University of Nebraska-Lincoln had a research project entitled Five Processes of Mathematical Thinking. The purpose of his study was to investigate key processes of mathematical thinking in his seventh grade Math classroom if he could affect the quality of student mathematical thinking and solution writing by teaching them the 5 key processes of mathematical thinking. The five mathematics processes applied by Scusa are the 5 process standards from the National Council of Teachers of Mathematics (NCTM, 2000) which are as follows: representation, reasoning and proof, communication, problem solving and connections. He thought that each of these processes standards from NCTM had a specific set of behaviors that one could use to characterize each. In his research, he concluded the following: he needed 1. to have faith in the teaching process skills and put more time in finding solution to help students; 2. to model the process and help students to "think" to learn on how to do the process; 3. to guide students to make visual reminders or checklists to lightened their journey; and 4. to be patient because although slow and sometimes hard to see, growth and positive changed happened.

From the research paper of Julie Ann S. Mirabueno, a Graduate Student of Bicol University, indicated that The Enhanced Basic Education Act of 2013, aim to develop productive and responsible citizens equipped with the essential competencies, skills and values for life-long-learning and consequently for employment (DepEd Order No. 43 S. 2013). One of the indicators of students learning is student performance assessment. Several assessment tools are administered by the Department of Education (DepEd) for specific purpose such as NCAE and NAT. The National Career Assessment Examination (NCAE) or simply Career Assessment is an inherent ability check meshed toward providing data through results of self-assessment, career awareness and career steerage of junior high school students. The National Achievement Test (NAT), an Exit Assessment, is a Philippine- made standardized test designed to determine students' achievement level, strengths and weaknesses in five curricular subject areas (English, Mathematics, Science, Filipino, and Social Sciences) at the end of the school year. (Mirabueno & Boyon, 2020, 5(3),p. 841).

Mathematics Framework for Philippine Basic Education. Mathematics is one of the five areas of study taken up at the Pre-K level all the way to college. The Philippine mathematics basic education curriculum has undergone several revisions over the years until such time that it was changed to K-12 Curriculum. The Science Education Institute, Department of Science and Technology (SEI-DOST) and the Philippine Council of Mathematics Teacher Education (MATHTED), Inc joined together to come up with a mathematics framework which is said to be continuing evolving and never be finished. This framework was a product of intense discussions with the best minds in the field of mathematics education, resulting from the very first forum launched in 2006 to 2011. The writers and contributors gave their best to make this mathematics curriculum framework into a comprehensive guide for all Filipino school mathematics teachers, mathematics educators, parents and school leaders. Leonarda Pascua said in 1993 that even there are many changes to the curriculum, the goals of mathematics education at the basic education level remain

more or less the same and that is, to provide opportunities for individuals to develop skills and attitudes needed for effective participation in everyday living and prepare them for further education and the world of work so that they make worthwhile contributions to the society at large (SEI-DOST & MATHTED, 2011). At our present time, students require stronger mathematical knowledge, skills and values to pursue higher education, to compete and be part of the technologically oriented workforce and to be informed citizens. They must have an understanding and be proficient in computing, problem solving, representing ideas and concepts and in connecting mathematics to other areas in life. Students must learn to use a variety of methods and tools to compute, including paper and pencil, mental arithmetic, estimation, calculators and computers. Technology and other hands-on tools must be used as an integral part of learning mathematics. The goal of mathematics education is to develop a mathematically empowered citizenry.

For Filipino students, the goal of Mathematical Empowerment focuses on developing critical and analytical thinking skills among all Filipino students. These skills encompass the following mathematical processes: Problem Solving, Communicating Mathematically, Reasoning, and Making Mathematical Connections. The vision of the framework is to achieve the focus goal through the teaching of a solid mathematical content, the development of strong cognitive skills and the promotion of desirable cognitive values to all Filipino students no matter their background or circumstance. In problem solving, a student thinks critically and analytically to be successful in finding correct solutions. Desirable problem solving skills include the ability to: 1) recognize that a problem exists; 2) identify or define the problem; 3) propose ways to solve the problem; 4) act on the proposed solutions and; 5) determine that the problem is solved. A student who thinks critically and analytically can communicate mathematical ideas using the precise language of mathematics (communicating mathematically). This includes the ability to use the special vocabulary and symbols of mathematics, represent and describe mathematical ideas and synthesize concepts and ideas through the use of mathematical structures and relationships. Reasoning and creating logical statements can be done by students who thinks critically and analytically. This includes the ability to use both deductive and inductive reasoning skills in order to make meaningful statements, justify steps in mathematical procedures and analyze arguments to determine whether conclusions are valid or not. And lastly, a student who is critically and analytically inclined can able to extend his/her thinking in order to connect mathematical ideas to other areas of study or aspects of life (making mathematical connections). This includes the ability to use a variety of representations – graphical, numerical, algebraic, verbal and physical – of mathematical ideas and apply concepts and procedures of mathematics to other disciplines or areas of study and aspects of life. (SEI-DOST & MATHTED, 2011, p.6).

Teaching Celestial Navigation. Nautical astronomy is an important subject for deck officers onboard merchant ships according to to the International Maritime Organization (IMO) Convention on Standards of Training , Certification and Watchkeeping (STCW). In the propose amendments to Chapter II of STCW Code, there is the mandatory requirement on knowledge and skills with respect to celestial navigation, but restricted to observation of the sun and stars , to determine the ship's position , and to the development of the method for celestial navigation (electronic nautical almanac and celestial navigation calculation software). The 2010 Manila amendments to the STCW Code maintained to use celestial bodies to know the ship's position as fundamental part of competency.

The construction of the European Higher Education Area set authors to create a new paradigm in teaching Celestial Navigation. (Ibanez, 2018). The new paradigm created focuses to several aspects as follows: a) Knowledge is discovered, constructed, transformed, and extended by students. b) Students are active constructors of their own knowledge. c) Learning is a social enterprise in which students need to interact with the instructor and classmates. d)-Instructor effort is aimed at developing student´s competencies. e)-Education is a personal transaction among students and between the instructor and students as they work together. f)All the above best take place within a cooperative context. g) Teaching is assumed to be a complex application of theory and research requiring considerable instructor training and continuous refinement of skills and procedures.

3. Methodology

Research Design. Research design is the overall strategy that researcher choose to integrate the different components of the study in a coherent and logical way to effectively address the problem of the research. Research design is a way to collect, analyze, interpret and report a data. The researchers of the study, Course Performance of Marine Transportation Students in Celestial Navigation (NAV4 233L3) Using Mathematical Processes: Basis for Course Enhancement, utilized embedded mixed-method design (quantitative and qualitative methods); and applied both the descriptive and inferential statistics. Mixed method research designs makes stronger qualitative and quantitative data, deepening and enriching qualitative results with quantitative data and validating quantitative findings with qualitative data. Mixed method was adopted since the qualitative data can support the result of the quantitative data to have a complete analysis of the study and expected to complement when summarizing the results. Since the open-ended questions were included as part of the quantitative survey, then the mixed method approach is an embedded design.(Fischler,n.d).

Population, Samples and Sampling Techniques. The participants were the Second Year BS Marine Transportation students enrolled in AIMS (Asian Institute of Maritime Studies) in the 3rd Trimester Academic Year 2021-2022 when NAV4 233L3 subject was offered. The sample was calculated using the Slovin's formula, that is the number of sample taken over the total population of Second Year BS Marine Transportation students under the 5% level of significance since the researchers do not know anything about the respondents except that they are all BS Marine Transportation enrollees. The desired sample was computed as 173 from the total population of 304 students. From the accumulated data, 182 was decided to be the sample after the data cleaning since their responses in the open-ended questions can be added in the thematic analysis.

Data Gathering Procedure. A request letter written by the researchers noted by the Dean of Center for Research and Institutional Development (CRID) addressed to the registrar's office was submitted to get a copy of the official grades for the NAV 3 and NAV4 233L3 courses taken the 3rd Trimester , Academic Year 2021-2022. The researchers send the link of the self-assessment course performance questionnaire in NAV4 233L3 via Google form to the roster of students. Purposive sampling technique was done since the sample depends on the number of BS Marine Transportation students who will participate to answer the questionnaire.

Research Instrument. In conducting the study, the researchers asked reputable persons in AIMS to validate the questionnaire and to test for its reliability. A request letter was sent to the registrar's office to get the official grades of the possible participants in NAV3 and NAV4 233L3. After determining the population of the enrolled students in NAV4 233L3, Slovin's formula was applied to get the sample for the study. A part of the population (20 students) were asked to answer the questionnaire via the link of the Google form to test for the reliability of the questionnaire. The survey is all about the students' profile and assessment on themselves regarding the mathematical processes which is based from the mathematical framework created by SEI-DOST & MATHTED in relation to topics taught in NAV4 233L3 (Celestial Navigation). Only 15 students participated the survey and the result of the reliability test was "excellent" so the questionnaire can be send to students. The students who will respond are the participants of the study in reference to the computed value from the Slovin's formula. Lastly, data will be collected for presentation, interpretation and analysis.

Statistical Treatment. Embedded mixed-method was applied in this study. Under the quantitative data, both descriptive and inferential statistics were used.

Descriptive Statistics. The profile or descriptive data (age, gender, senior high school strand, NAV 3 grades and NAV4 233L3 grades) in problem 1; and the categories of topics in NAV4 233L3 in problem 2 are summarized in tabular presentations. The frequency and percentage values of the descriptive data were reflected in the table to describe the age, gender, senior high school strand, NAV3 grades and NAV4 233L3 grades.

Inferential Statistics. Problems 3 and 4 were interpreted using inferential statistics and could answer the two hypotheses statements. The independent and dependent variables (NAV3 and NAV4 233L3 grades, respectively) in problem 3 were correlated using Pearson correlation analysis. This statistical treatment is used to find the relationship between and among the values in the grades of the respondents. The result of this statistics answer the first hypothesis statement, H01. The independent variables (age, gender and senior high school strand) were compared to the means of each criterion in problem 2, the self-assessment course performance of the respondents. Analysis of Variance (ANOVA) is the statistical treatment applied in problem 4 that answers the second hypothesis, H02.

Under the qualitative data gathered from numbers 5 and 6, thematic analysis was used. The responses are grouped according to the similar phrases arriving with specific themes. The descriptive and inferential statistics were tabulated using Microsoft Excel; and described, analyzed and interpreted with the aid of SPSS (Statistical Package for the Social Sciences) version 29. The result was validated by a statistician.

4. Results

The result of the gathering of data and the conduct of survey with its analysis and interpretation are as follows.

1. Demographic Profile of 2nd Year BS Marine Transportation Students (3rd Trimester, AY 2021-2022)

Table 2. Number of Respondents According to Age, n=182

AGE OF RESPONDENTS	FREQUENCY	%
less 18	2	1.10

18 to 19	1	0.55
20 to 21	121	66.48
22-23	53	29.12
24 and above	5	2.75
TOTAL	**182**	**100**

The data, Age Distribution of the Respondents, shows that 66.48% respondents are 20 to 21 years old, 29.12 % respondents are 22 to 23 years old, and the rest is 4.4% respondents (8 out of 182) are below 20 years old and above 23 years old. The age of the respondents are mostly 20 to 21 years old which could be based in pursuant to the Kindergarten Education Act of 2012 (Republic Act No. 10157) wherein the prerequisite age of the Filipino children entering Kindergarten is 5 years old by June 1 every calendar year. So as the time they are in Second Year College, their age is around 20 years old. Likewise, others may stop for a trimester since there is a covid-19 outbreak in 2020.

Table 3. Number of Respondents According to Gender, N=182

GENDER	FREQUENCY	%
Male	168	92.31
Female	9	4.95
Prefer not to say	5	2.75
TOTAL	**182**	**100**

Table 3 shows that 92.31% of the enrollees were male. It is a fact since men dominated employment on ships. Giorgio Carrozi (2021) said that in 1.9 million seafarers , 98% are men; and only 30% of women employed on board reached ranked officer. Carrozi mentioned that the employment of women is gradually increasing since 2015.

Table 4. Number of Respondents According to Senior High School Strand (SHS) Track, n=182

SHS TRACK TAKEN BY RESPONDENTS	FREQUENCY	%
STEM	83	45.60
HUMMS	29	15.93
GAS	16	8.79
ABM	17	9.34

TVL	19	10.44
SPORTS	1	0.55
OTHERS	17	9.34
TOTAL	**182**	**100**

Table 4 indicates that 45.60% had taken STEM strand, followed by 15.93% HUMMS strand. The participants were aware that to be seafarer in the future, one should equipped his self with the technical knowledge needed to work in a ship. The STEM strand (Science, technology, Engineering and Mathematics) is a good choice for maritime courses to have the opportunity of being an officer on board ship.

Table 5. Number of Respondents According to Final Grade in NAV 3, N=181

GRADE IN NAV3	FREQUENCY	%
1.00 (Excellent)	0	0.00
1.25 (Outstanding)	11	6.08
1.50 (Distinction)	21	11.60
1.75 (Superior)	40	22.10
2.00 (Very Good)	50	27.62
2.25 (Good)	37	20.44
2.50 (Satisfactory)	14	7.73
2.75 (Fair)	4	2.21
3.00 (Passed)	2	1.11
5.00 (Failed)	2	1.11
TOTAL	**181**	**100**

The respondents in Table 5 is only 181 instead of 182. It tells that one of the enrollees in NAV4 233L3 did not enrol in NAV 3. From the respondents, 6.08% got the highest grade of 1.25 (Outstanding). The 27.62% of the participants got 2.00 (Very Good), 22.20% got 1.75 (Superior), 20.44% got 2.25 (Good), 11.60% got 1.50 (Distinction), 7.73% got 2.50 (Satisfactory), 6.08% got 1.25 (Outstanding), 2.21% got 2.75 (Fair) and 1.11% got 3.00 (Passed). Two of the respondents (1.11%) got 5.00 (Failed) in NAV3 . The grades of the respondents is fair enough since more than 98% passed the subject.

Table 6. Number of Respondents According to Final Grade in NAV 4 233L3, n=178

GRADE IN NAV 4	FREQUENCY	%
1.00 (Excellent)	4	2.25

1.25 (Outstanding)	16	8.99
1.50 (Distinction)	29	16.29
1.75 (Superior)	66	37.08
2.00 (Very Good)	36	20.22
2.25 (Good)	16	8.99
2.50 (Satisfactory)	6	3.37
2.75 (Fair)	4	2.25
3.00 (Passed)	1	0.56
5.00 (Failed)	0	0.00
TOTAL	178	100

In Table 6, 2.25% of the respondents (4 out of 178) achieved the highest grade of 1.00 (Excellent). The 37.08% of the respondents got 1.75 (Superior), 20.22% got 2.00 (Very Good), 16.29% got 1.50 (Distinction), 6.99% got 1.25(Outstanding) and 2.25(Good). None of the respondents failed the subject and it is very admirable. The sample size is not equal to 182 since the respondents in NAV 3 did not enrol in NAV4 233L3 especially those who failed NAV3.

How did the AIMS maritime transportation students perform in Celestial Navigation (NAV 4 233L3) based on their self-assessed mathematical processes application ?

The mean distribution in Table 7 reflects the course performances (self assessment) applying mathematical processes in NAV4 233L3. The respondents “agree” (over all weighted mean = 3.14) to all the course performances (self assessment) applying mathematical process. It means that respondents apply their mathematical skills in learning the topics in NAV4 233L3 particularly the processes of problem solving, communicating mathematically , reasoning and making mathematical connections.

The highest weighted mean is 3.20 (agree) under the topic, 2.1.
Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac. Under topic 2.1 , the highest math process or skill is 2.1.1. Problem Solving with mean, 3.25 (agree), followed by 2.1.2. Communicating Mathematically with mean, 3.21 (agree), then by 2.1.4. Making Mathematical Connections with mean, 3.19 (agree) and the lowest is 2.1.3. Reasoning with mean 3.15, (agree). Under topic 2.1., respondents agree that they are favorable in problem solving (as highest mean of 3.25) particularly in solving problems related to the Position of the Body,Time of Sunrise and Sunset, and Twilight using Nautical Almanac. The least favorable is Reasoning that is justifying and proving answers when solving compass error. With this, the instructor should add more time in this criteria of reasoning since this is unlikely favorable to students (Ibanez,2018). The second highest weighted mean are 2.4.Usage and Content of Sight Reduction Table and Intercepted Method

and 2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun, with mean, 3.14 (agree).

The highest mathematical process applied under topic 2.4. is 2.4.4. Making Mathematical Connections with mean of 3.14 (agree), followed by 2.4.1 Problem Solving and Reasoning with mean of 3.13 (agree) and by 2.4.2. Communicating Mathematically with mean of 3.11 (Agree). The respondents agree that the most favorable mathematics process under topic 2.4 is making math connections , that is students are competent enough to apply numerical computations . However, the least favorable is communicating mathematically, that is the students can explain how to manipulate and plug-in the values in the Sight Reduction Table. The instructor should give time demonstrating properly on how to make use and manipulate Sight Reduction Table.

Innovative approach and facilitate practical learning is needed in teaching Celestial Navigation. (Ibanez,2018)

For topic 2.2., the highest Mathematical Process is 2.2.4. Making Mathematical Connections with mean of 3.15 (agree), followed by 2.2.2. Communicating Mathematically with mean of 3.14 (agree), then by 2.2.3. Reasoning with mean of 3.12 (agree) and by 2.2.1. Problem Solving with mean of 3.11 (agree). The respondents agree that they are favorable to the mathematical process of making mathematical connections particularly in having the ability to use numerical computations and conversions to solve compass error problems. On the other hand, the least favorable process is problem solving specifically in identifying compass error and proposing a solution applying Azimuth of the sun, Azimuth of the Stars and Amplitude of the Sun. The instructors in NAV4 233L3 should add more activities in solving compass error and how to apply Azimuth of the sun, Azimuth of the Stars and Amplitude of the Sun in problem solving. (Ibanez, 2018) Lastly the topic that has the lowest weighted mean is 2.3. Solving problems using Marine Sextant with a mean of 3.09 (agree), The highest math process under this topic is 2.3.2. Communicating Mathematically with a mean of 3.13 (agree) , followed by 2.3.4. Making Mathematical Connections with a mean of 3.09 (agee) , then by 2.3.3. Reasoning with a mean of 3.07 (agree) and the last is 2.3.1. Problem Solving with a mean of 3.05 (agree). The favorable math process under this topic is communicating mathematically particularly in defining and explaining the following terms: sextant altitude, apparent altitude and observed altitude. And the least favorable is problem solving which is concern in solving sextant and observed altitudes. Since topic 2.3. Solving problems using Marine Sextant has the lowest mean (3.09, agree) , the instructor of NAV4 233L3 should extend discussing this topic specifically in solving problems using the Marine Sextant. Instructors should adjust their course planning, and develop an environment that can help students' academic performance and course experience.

3. Is there a significant relationship between the NAV3 grade and the NAV4 233L3 grade of the marine transportation students (respondents)?

Table 8. Relationship Between the Grades of NAV 3 and NAV 4 233L3 of Marine Transportation Respondents

Subjects	No. of Respondents, n	Pearson Correlation, r	p-value	Interpretation
NAV 3	181	.244	<.001	significant
NAV 4 233L3	178			

The table presents the relationship between the official final grades of BS Marine Transportation students enrolled in the 3rd Trimester Academic Year 2021-2022 in NAV3 and NAV4 233L3 and they are significantly correlated. The values are taken from the utilization of SPSS software version 29. The results of Pearson Correlation analysis revealed that the official grades in NAV 3 and NAV4 233L3 has a positive correlation , r= .24, p< .001 using significant level, a = 0.05 in 1-tailed distribution. It means that as the NAV 3 grade increases , the NAV 4 grade also increases with respect to the grades of the respondents enrolled in NAV 4 233L3 in the 3rd Trimester , Academic Year 2021-2022. Hence, the first null hypothesis, H_{01}, is rejected since there is a significant positive weak relationship between the grades in NAV 3 and NAV4 233L3 among the respondents.

4. Is there a significant difference in the course performance of marine transportation students applying mathematical processes in Celestial Navigation (NAV4 233L3) when they are grouped according to their profile?

Table 9. Comparison of the Course Performance of Marine Transportation Students applying Mathematical Processes in NAV4 233L3 when Grouped according to Age, n=182.

Course Performances in NAV 4 233L3	F	p-value	Interpretation
2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac	1.818	0.127	Not Significant
2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun	1.769	0.137	Not Significant
2.3. Solving problems using Marine Sextant	1.728	0.146	Not Significant
2.4. Usage and Content of Sight Reduction Table and Intercepted Method	1.758	0.139	Not Significant

Table 9 indicates the comparison of the course performance of marine transportation students applying mathematical processes when grouped according to age. Using Analysis of Variance, the p-value of the course performances are as follows: 2.1.Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac has p = .127, p > .05, 2.2 Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun, p= .137 , p>-.05, 2.3. Solving problems using Marine Sextant , p=.146 and 2.4. Usage and Content of Sight Reduction Table and
Intercepted Method , p=.139, p>.05. There will be a significant difference if p value of the variables has p < .05 and along with this is the rejection of the hypothesis. Hence, in the comparison of course performance applying mathematical processes when grouped according to age , there is no significant difference and the null hypothesis, H_{02}, is accepted.

Table 10. Comparison of the Course Performance of Marine Transportation students Applying Mathematical Processes when Grouped According to Gender, n=182

Course Performances in NAV 4 233L3	F	p-value	Interpretation
2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac	.091	.913	Not Significant
2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun	.155	.856	Not Significant
2.3. Solving problems using Marine Sextant	.150	.861	Not Significant
2.4. Usage and Content of Sight Reduction Table and Intercepted Method	.432	.650	Not Significant

Table 10 indicates the comparison of the course performance of respondents applying Math processes when grouped according to gender. The p value of 2.1 Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac is p= .913, p>.05; 2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun, p=.856, p>.05, 2.3. Solving problems using Marine Sextant , p=.861. p>-.05, and 2.4. Usage and Content of Sight Reduction Table and Intercepted Method, p=.650,p>.05. All the p values of the course performance is p>.05, hence there is no significant difference among the means in the course performance when grouped according to gender, and the null hypothesis, H_{02} is accepted.

Table 11. Comparison of the Course Performance of Marine Transportation Students Applying Mathematical Processes when Grouped According to Senior High School (SHS) Strand, n= 182

Course Performances in NAV 4 233L3	F	p-value	Interpretation
2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac	.215	.972	Not significant
2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun	.463	.835	Not significant
2.3. Solving problems using Marine Sextant	.881	.510	Not significant
2.4. Usage and Content of Sight Reduction Table and Intercepted Method	.737	.621	Not significant

Table 11 indicates the comparison of the course performances of the respondents when grouped according to Senior High School (SHS) strand. The p values of the course performance are the following: 2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac is p=.972,p>.05, 2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun,p=.835,p>.05, 2.3. Solving problems using Marine Sextant, p=.510,p>.05, and 2.4. Usage and Content of Sight Reduction Table and Intercepted Method, p=.621 , p>.05. All the p values are greater than .05 so there is no significant difference among the means of the

course performance when grouped according to Senior High School (SHS) strand. The null hypothesis, H_{02} is accepted.

Table 12. Comparison of the Course Performance of Marine Transportation Students Applying Mathematical Processes when Grouped According to the Grade in NAV 3 , n=180

Course Performances in NAV 4 233L3	F	Pvalue	Interpretation
2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac	2.222	.028	Significant
2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun	1.651	.114	Not Significant
2.3. Solving problems using Marine Sextant	1.953	.055	Not Significant
2.4. Usage and Content of Sight Reduction Table and Intercepted Method	2.104	038	Significant

Table 12 shows the comparison of the Course Performance of marine transportation students applying mathematical processes when grouped according to grade in NAV3. There is no significant difference in 2.2. Compass error by Azimuthal of the sun, Azimuthal of the stars and Amplitude of the Sun having p value= .114 , p> .05 and in 2.3. Solving problems using Marine Sextant , p=.055 , p>.05 . There is significant difference in 2.1. Determining position of the body , time of sunrise and sunset and twilight using Nautical Almanac, p= .028, p<.05 and 2.4. Usage and content of sight reduction table and intercepted method , p=.038, p<.05. The significant difference tells that there are differences among the means when grouped according to the grades of NAV 3, hence the hypothesis,$H_{02,}$ is rejected. Similarly, 2.4. Usage and Content of Sight Reduction Table and Intercepted Method, p=.028, p<0.05. The significant difference tells that there are differences among the means when grouped according to the grades of NAV 3, hence the hypothesis,$H_{02,}$ is rejected. Locating the difference in means when grouped according to grade in NAV 3, a Post Hoc Test run was done using SPSS. The Tuckey Test does not show any group that shows significant difference (p<.05) since the sample size of the respondents who answer the survey and the respondents taken from the grade of NAV3 are not equal. But it can be observed that the means of the grade of the respondents in NAV3 when being grouped are different from each other. (See appendix)

Table 13. Comparison of the Course Performance of Marine Transportation students applying Mathematical Processes according to Grade in NAV 4

Course Performances in NAV 4 233L3	F	p-value	Interpretation
2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac	1.266	.264	Not Significant

2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun	.762	.636	Not Significant
2.3. Solving problems using Marine Sextant	1.006	.433	Not Significant
2.4. Usage and Content of Sight Reduction Table and Intercepted Method	.800	.603	Not Significant

Table 13 presents the comparison of course performance of respondents applying mathematical processes when grouped according to grade in NAV 4 233L3. The p values of the course performances are as follows: 2.1. Determining Position of the Body, Time of Sunrise and Sunset, and Twilight Using Nautical Almanac, p =.264,p>.05, 2.2. Compass Error by Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun, p=.636, p>.05, 2.3. Solving problems using Marine Sextant, p=.433,p>.05, and 2.4. Usage and Content of Sight Reduction Table and Intercepted Method, p=.603,p>.05. All the p values are greater than .05 so there is no significant difference when the means of the course performance are grouped according to the grade in NAV4 233L3. Embedded in the questionnaire are two open-ended questions. After the respondents are asked about their self assessment in the course performance applying math processes in NAV4 233L3, two open ended questions were included. It will guide them to tell their interests and difficulties they experienced in NAV4 233L3. The supplemental qualitative method will help the researchers to know deeper the result of the self assessment survey.

Thematic analysis was utilized to interpret the responses.

5.What activity , laboratory work or topic that the respondents are interested with upon taking NAV4 233L3?

Three themes yielded from the responses: problem solving is interesting; NAV4 233L3 has interesting topics; and interesting Laboratory Activities: Using Nautical Almanac, Marine Sextant, and Sight Reduction Table. Part of the responses are indicated as follows: Problem Solving is Interesting. Participants find it interesting and challenging to solve problems. It can be reflected to some part of their answers in the survey. The highest mean in the survey is, 2.1.1. I can solve problems related to the Position of the Body,Time of Sunrise and Sunset, and Twilight using Nautical Almanac (Problem Solving) mean=3.25 (agree). Some of the responses are as follows:

“All topics that have computations because I like numbers and I find it interesting.”

“Solving Intercept and Azimuth in celestial navigation using Sight Reduction Tables.”

“I think the computations true bearing, gyro error and true course.”

“Topic related in computation, why? Since I am not that good in computation, i am willing to enhance and learn more about this problem/topic.”

" Solving compass error"

“Solving and plotting data.”

NAV4 233L3 has interesting topics. Participants have specific topics that they are interested in NAV 4 233L3. They are interested in using Compass Error, about celestial sphere and systems coordinates, and exploring Nautical Almanac among others. Since they are marine transportation students , they are fascinated on topics related to navigation. From the Standards of Training and Watchkeeping (STW), there should be the mandatory requirement on knowledge and skills with respect to celestial navigation, but restricted to observations of the sun and stars, to determine the ship’s position, while improving

the method for celestial navigation calculation. The students should continue to widen their awareness on the topics of Celestial Navigation.Some of the responses are as follows:

"One of the topics in NAV 4 that I like is about the Compass Error by
Azimuthal of the Sun , Azimuthal of the Stars, and Amplitude of the Sun."

"I think this is is the most interesting activity that we did in NAV 4, celestial sphere and its system of coordinates."

"The Nautical Almanac. It contains astronomical data for entire year."

" I remembered the topic I learned in navigational 4 the Traditional sextants have a half-horizon mirror, which divides the field of view in two. On one side, there is a view of the horizon on the other side, a view of the celestial object. The advantage of this type is that both the horizon and celestial object are bright and as clear as possible.

Interesting Laboratory Activities: Using Nautical Almanac, Marine Sextant, and Sight Reduction Table. There are participants who recall their activities in the laboratory. This can be associated with some of the respondents who have interests with the the different topics but there is manipulation of tools or devices. Future deck officers should be familiarized and be knowledgeable on how to use these instruments.Some of the responses are as follows:

"Using the Marine Sextant. Although it is difficult to use, it is interesting to see how it is used."

"Use of sight reduction tables."

"Determining position of the body, time of sunrise and sunset using nautical almanac."

6.What activity , laboratory work or topic that the respondents find difficult to understand in NAV4 233L3?

The answers are summarized and interpreted using thematic analysis. There are also three themes produced in problem 6: NAV 4 233L3 is not difficult: The instructor discussed the topics well; Crucial in NAV4 233L3:Problem Solving; and NAV4 233L3 Math Connections is Hard: Plotting, Completing Tables and Math Equations. NAV 4 233L3 is not difficult: The instructor discussed the topics well. Some respondents answer no, none or all of the topic is understandable. They say that their instructors play a big part in their academic performance and achievement in Celestial Navigation. The instructors hired in Asian Institute of Technology have working experiences on board with the least rank of Officer-In-Charge Navigational Watch or deck officer. Some of the responses are as follows:

"There's none because the professor explains it very well to us and the discussion went smoothly so I think there is none."

"I think there's none because the professor during my NAV4 subject discuss the topics very well."

Crucial in NAV4 233L3: Problem Solving. Some respondents find it difficult to do problem solving. Each of NAV4 233L3 are crucial as mentioned by corresponding group of marine transportation students. They find it hard to solve position of the body, time of sunrise and sunset , and twilight using nautical almanac; to solve compass error by azimuthal of the sun and stars , and amplitude of sun; to solve problems using marine sextant; and to compute problems using sight reduction table and intercepted method. Some of the direct answers are as follows:

"Compass error by azimuthal of the sun, azimuthal of the stars, and amplitude of the sun. I find it difficult, but not all of it because it has many formulas and patterns for you to come up an answer."

"Identifying and correcting a complicated compass error situation."

"Solve problems involving sextant and observed altitudes."

NAV4 233L3 Math Connections is Hard: Plotting, Completing Tables and Math Equations. Few students find it hard in general to do plotting and to solve math equations specifically in substituting the right values to accomplish the tables. If students have hard time to connect the simple concepts such as plotting, completing tables and math connections to real life application, the instructor should give meaningful active learning activities in combination with cooperative learning. It has been proven that cooperative learning increases student achievement and creates positive relationships between students.(Ibanez, 2018). Some of the respondents are as follows: "The topic that I find difficult to understand in NAV 4 is about the usage and content of sight reduction table and intercepted method." "Anything math related. I tend to have a difficulty with it comes to solving mathematical equations." "It is looking in the table it is difficult to understand in first few weeks but the time goes by it is getting easier to understand."

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