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Applications of Plane and Spherical Triangle Solutions in Terrestrial Navigation Problems

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ABSTRACT

The study determined the applications of plane and spherical triangle solutions in terrestrial navigation problems among maritime students at Biliran Province State University, Naval, Biliran, Philippines. Its specific goals were to: (1) measure the distance in terms plane sailing, traverse sailing, middle latitude sailing, and mercator sailing; (2) ascertain the accuracy, applicability, and efficiency rate of plane and spherical triangle solutions in terrestrial navigation problems; (3) examine the significant relationship between applicability and accuracy on plane and spherical triangle solutions on terrestrial navigation problems. The descriptive research design was utilized, and the study was conducted from August to November 2023. There were sixty (60) involved respondents. The data retrieved and analyzed using mean and level of significance at 0.05. Results revealed that plane and spherical triangle solutions were accurate, applicable, and efficient in terrestrial navigation problems and there is no significant difference between plane and spherical solutions.

1. Introduction.

Plane and spherical trigonometry were areas of Mathematics. Some of the applications were used in land measurements, surveying, astronomy, and navigation. Plane triangle is a closed figure bounded by three-line segments in a flat or level surface in two-dimensional plane that has six (6) parts: three sides and three angles. But a spherical triangle is a closed figure bounded with three-line segments in a closed curved surface called a sphere, where every point of which is equidistant from a fixed point known as the center (Ramirez, 2011).

A spherical triangle is a portion of the surface of the sphere bounded by arcs of three great circles. Same with plane triangles, spherical triangles also have six parts: three sides and three angles.

Generally, the angles are denoted by A, B and C and the corresponding sides by a, b, & c where these angles and sides were used to solve the problems in navigation.

In navigating at sea, there were three types: electronic navigation (Sonnenberg, 2013), celestial navigation (Seidelmann & Hohenkerk, 2020), and terrestrial navigation (Bowditch, N. & Bowditch, J. I., 1883). However, the present study focused only on the applications of plane and spherical triangle solutions in terrestrial navigation because this type of navigation uses landmarks such as lighthouses, buoys, headlands, and other objects on the surface of the Earth (Ynion, 2003).

One of the methods in terrestrial navigation is the concept of sailing. These sailings were Plane sailing (Cotter, 1978), Traverse sailing (Sidoti, Pattipati & Bar-Shalom, 2023), Middle-latitude sailing, and Mercator sailing (Nicolai, 2018).

All these sailings would refer to the mathematical solution of problems involving finding courses and distances from one known point to another. Plane and spherical triangle solutions are chosen concepts in trigonometry which is extremely important in navigating the ships to understand the accuracy, applicability, and efficiency of the applications in terrestrial navigation problems. Thus, this study was conducted to guide maritime personnel to navigate ships safely.

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2. Statement of the Problem.

This study determined the applications of plane and spherical triangle solutions in terrestrial navigation among maritime students at Biliran Province State University-Naval.

Specifically, it sought to answer the following objectives:

1. Measure the distance from Naval Port to Palompon Port using plane and spherical triangle solutions as to: Plane sailing; Traverse sailing; Middle latitude sailing and Mercator sailing.
2. Determine the rate of accuracy, applicability, and efficiency of plane and spherical triangle solutions in terrestrial navigation problems.
3. Analyze the significant relationship between applicability and accuracy on plane and spherical triangle solutions in terrestrial navigation problems.

3. Methodology.

This section presents the research design, respondents of the study, locale of the study, research sampling techniques, research instrument, data gathering procedures, and data analysis.

3.1. Research Design.

This study used descriptive-correlation research design. The design was descriptive because this would describe the accuracy, applicability, and efficiency of plane and spherical triangle solutions in terrestrial navigation problems and correlates the significant relationship between variables respectively.

3.2. Respondent of the Study.

The research respondents of this study were nautical students enrolled in maritime programs at Biliran Province State University-Naval.

Table 1: Distribution of respondents.

Course	*No. of Respondents*	*Percentage*
BSMT IIA	30	50%
BSMT IIB	20	33%
BSMT IIC	10	17%
Total	60	100%

Source: Authors.

3.3. Locale of the Study.

The study was conducted from August to November 2023 in the Department of Maritime Education at Biliran Province State University.

3.4. Research Sampling.

This study used Sloven's to determine the research sample size of 60 deck cadets out of 100 total populations.

3.5. Research Instrument.

This study utilized a researcher-made instrument that undergone dry-run and validated of the University Research and Innovation Office at Biliran Province State University to ensure that the utilized survey instrument was reliable to gather relevant information of the study.

3.6. Data Gathering Procedures.

The letter request was sent to the University President for approval in conducting the research study. After the approved letter, a researcher-made questionnaire was crafted. Then, this will be distributed to the identified respondents in the college. The respondents were asked to rate the accuracy, applicability, and efficiency of plane and spherical triangle solution in terrestrial navigation problems.

3.7. Data Analysis.

The data gathered, collected, and analyzed using the exact statistical tools. Mean was used to analyze the accuracy, applicability, and efficiency of plane and spherical triangle solution in terrestrial navigation problems, and person r correlation for the significant relationship between the plane and spherical triangle solutions in terrestrial navigation on its accuracy, applicability, and efficiency.

3.8. Data Scoring.

Table 2: Data Scoring.

Scale	*Range*	*Verbal Description*
5	4.21–5.00	Very much accurate/applicable/efficient
4	3.41–4.20	Much accurate/applicable/efficient
3	2.61–3.40	Accurate/Applicable/Efficient
2	1.81–2.60	Slightly accurate/applicable/efficient
1	1.00–1.80	Not accurate/applicable/efficient

Source: Authors.

4. Results & Discussion.

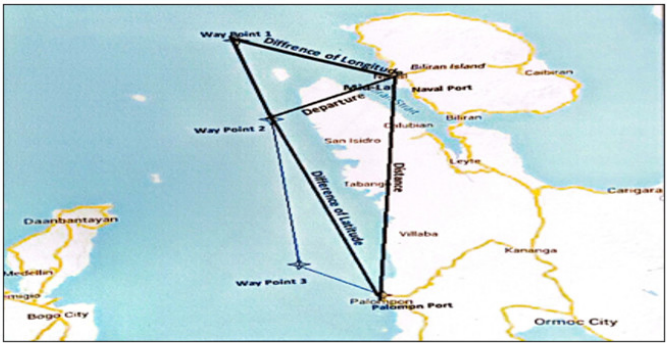
4.1. Distance from Naval port to Palompon port using Plane and Spherical triangle solutions as to: Plane sailing; Traverse sailing; Middle latitude sailing and Mercator sailing as shown in tables 3, 4, 5 and figures: 1, 2, 3, and 4.

Table 3: Distance from Naval Port to Palomport based on Plane sailing.

Waypoint	**Distance**
Naval Port – Waypoint 1	5.11 nautical miles
Waypoint 1 – Waypoint 2	6.43 nautical miles
Waypoint 2 – Waypoint 3	26.28 nautical miles
Waypoint 3 – Palompon Port	2.13 nautical miles

Source: Authors.

Figure 1: Distance from Naval Port to Palompon Port - Plane sailing.



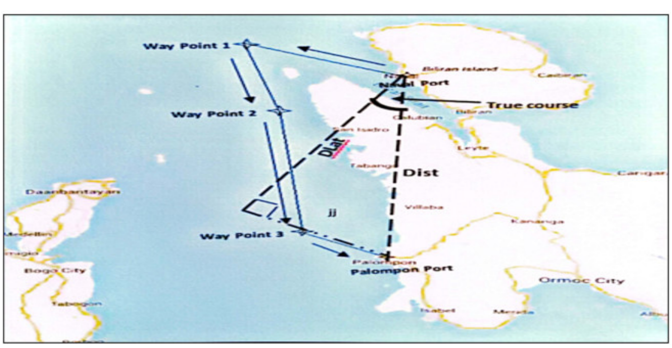
Source: Authors.

Table 4: Distance from Naval Port to Palomport based on Traverse sailing.

Waypoint	Distance
Naval Port – Waypoint 1	5.11 nautical miles
Waypoint 1 – Waypoint 2	6.43 nautical miles
Waypoint 2 – Waypoint 3	26.28 nautical miles
Waypoint 3 – Palompon Port	2.13 nautical miles

Source: Authors.

Figure 2: Distance from Naval Port to Palompon Port - Traverse sailing.



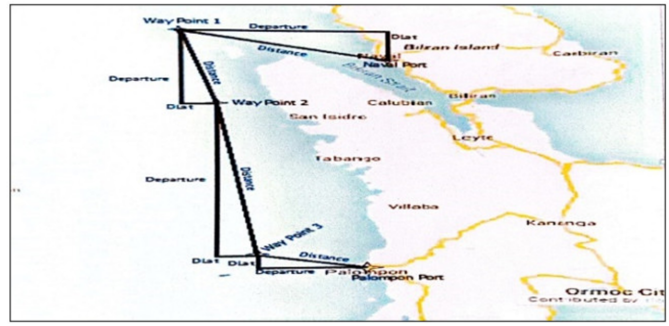
Source: Authors.

Table 5: Distance from Naval Port to Palomport based on Middle latitude sailing.

Waypoint	Distance
Naval Port – Waypoint 1	5.11 nautical miles
Waypoint 1 – Waypoint 2	6.43 nautical miles
Waypoint 2 – Waypoint 3	26.28 nautical miles
Waypoint 3 – Palompon Port	2.13 nautical miles

Source: Authors.

Figure 3: Distance from Naval Port to Palompon Port based on Middle latitude sailing.



Source: Authors.

Table 6: Distance from Naval Port to Palompon Port based on Mercator sailing.

Waypoint	Distance
Naval Port – Waypoint 1	5.11 nautical miles
Waypoint 1 – Waypoint 2	6.43 nautical miles
Waypoint 2 – Waypoint 3	26.28 nautical miles
Waypoint 3 – Palompon Port	2.13 nautical miles

Source: Authors.

Figure 4: Distance from Naval Port to Palompon Port - Mercator sailing.

Source: Authors.

4.2. Determine the rate of accuracy, applicability, and efficiency of plane and spherical triangle solutions in terrestrial navigation problems.

4.2.1. Plane triangle solution. See table 7.

The accuracy, applicability, and efficiency of plane and spherical triangle solutions in terrestrial navigation problems as shown in table 7. Results revealed that accuracy got highest mean with 3.96, applicability obtained 3.93, and efficiency 3.68. These three indicators shown that the spherical triangle solution was much accurate, applicable, and efficient in terrestrial navigation problems.

Table 7: Rate of accuracy, applicability, and efficiency of plane triangle solutions in terrestrial navigation problems.

Plane Triangle	Mean	Description
Accuracy	4.28	Very much accurate
Applicability	4.23	Very much accurate
Efficiency	4.22	Very much accurate

Source: Authors.

4.2.2. Spherical triangle solutions. See table 8 below.

Table 8: Rate of accuracy, applicability, and efficiency of spherical triangle solutions in terrestrial navigation problems.

Spherical Triangle	Mean	Description
Accuracy	3.96	Much accurate
Applicability	3.93	Much applicable
Efficiency	3.68	Much efficient

Source: Authors.

The accuracy, applicability, and efficiency of plane and spherical triangle solutions in terrestrial navigation problems as shown in table 8. Results revealed that accuracy got highest mean with 3.96, applicability obtained 3.93, and efficiency 3.68. These three indicators shown that the spherical triangle solution was much accurate, applicable, and efficient in terrestrial navigation problems.

4.3. Significant difference between applicability and accuracy on plane and spherical triangle solutions in terrestrial navigation problems. See table 9 below.

Table 9: Significant relationship of means between applicability and accuracy on plane and spherical triangle solutions in terrestrial navigation problems.

Variables	Mean	c-value	p-value.
Plane triangle solutions	4.243	0.598	0.000
Spherical triangle solutions	3.856	0.375	0.000

When p > 0.05. No significant difference

Source: Authors.

It can be seen from the results that the plane triangle solution with respect to its applicability and accuracy was found to be significant with *p-value* of 0.000 and with the coefficient of 0.598. In spherical triangle solution with respect to its applicability and accuracy was also found to be significant with *p-value* of 0.000 and with the correlation coefficient of 0.375. The null hypothesis that there is no significant difference between plane and spherical triangle solution in terrestrial navigation problems as perceived by the respondents on the applicability and accuracy of plane and spherical triangle solutions was rejected at 0.05 level of significance. It means, when the rate of applicability increases, accuracy also increases both plane and spherical triangle solutions. Findings revealed that when plane and spherical triangle solutions were applied in terrestrial navigation problems, this will obtain very much accurate, applicable, and efficient results.

Conclusions.

Plane and Spherical triangle solutions were very accurate, applicable, and efficient in terrestrial navigation problems. There was no significant difference between plane and spherical triangle solutions in terms of accuracy, applicability, and efficiency in terrestrial navigation. Thus, apply the plane and spherical triangle solutions in terrestrial navigation to navigate ships safely from one port to another.

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