

# MAAPCNIA: a boost to authentic MET instruction

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**ABSTRACT:** This paper presents an innovation in teaching strategy in one major subject in the Maritime Education and Training (MET) program of the Maritime Academy of Asia and the Pacific (MAAP). This strategy makes use of an instructional aid called MAAPCNIA (MAAP Celestial Navigation Instructional Aid), conceptualized and designed by Capt. Daniel S. Torres, Jr. MAAPCNIA encompasses color-coded spheres that depict navigational triangle. This triangle is composed of a blue celestial sphere representing horizon system of coordinates and a white sphere enclosing a globe characterizing time diagram and celestial equator and terrestrial systems of coordinates. With this instrument, celestial spheres can be easily visualized compared when using one-dimensional drawing. Hence, understanding of orthographic projection, which is essentially the core of appreciation and mastery of this tough subject, is enhanced. This paper focuses on the development and impact of MAAPCNIA since its conception in 2004, towards authentic teaching-learning process in Celestial Navigation.

## 1 AUTHENTIC INSTRUCTION: THE CHALLENGE IN MET

The increasing demand for competent marine officers in the world fleet greatly relies on the quality of Maritime Education and Training (MET). During the 3<sup>rd</sup> LSM Conference in 1999, Dr. M. Aziz presented his concepts in MET. In his presentation, he stressed that “investment in human resources are based on two main elements, education and training. Education nowadays is concerned with change, as the environment is constantly challenged with the problems of obsolescence. Education is understood to be the process of cultivating intellectual power by imparting knowledge and developing the mind. The process of training could be identified as the activity for acquiring specialized skill to perform certain work or tasks, through instruction and practice. In other words, training can be identified as the process of teaching skills. The correlation between education and training deals with the interrelationship between knowledge and skill. Education directly deals with knowledge, and training deals with the skills. The careful blending of education and training is the best way to achieve objectives.”

Chugani (1997) stated that “just as anything else, for survival, an educational programme has to be dynamic and evolutionary. In a vast ocean of unknown, an individual needs guidance, but with liberty to roam, explore and to challenge the most established theories, concepts, and practices to ensure one’s place in an unending race for

excellence.” He said that the only barrier is resistance to change. Nevertheless, educational research and development is gaining popularity in the academe, to include MET, because of its evident effectiveness in bridging the gap between research and classroom practice and in its emphasis upon scientific evaluation. This is one of the commitments of the Maritime Academy of Asia and the Pacific (MAAP), to support and promote quality and excellence in MET. Towards this end, members of the academe are progressing towards better teaching methods and strategies and interactive materials that would facilitate learning among students and boost authentic instruction, hence, bringing about educational change.

Realizing the significance of Research and Educational Development, a senior lecturer and master mariner conceptualized an instructional aid to enhance teaching and learning in the subject - Celestial Navigation, which is essentially one of the core subjects in the Bachelor of Science in Marine Transportation (BSMT) curriculum. This paper presents the conceptualization, design, composition, and impact of this teaching aid in celestial navigation called MAAPCNIA.

## 2 THE CELESTIAL NAVIGATION SUBJECT

Celestial Navigation is one of the six basic types or methods of navigation that enhances a mariner’s ability to complete his voyage safely and expeditiously. It involves the study of heavenly

bodies to aid mariners in fixing their position at sea. It includes reading celestial measurements to lines of positions using tables, spherical trigonometry and almanacs. It is used primarily as a backup to satellite and other electronic systems in the open ocean. Because of the importance of this subject, an instructional aid is designed for the students to understand computations derived from various formulas rather than just memorize these measures without an in-depth comprehension of the subject. Celestial Navigation encompasses the following concepts: (1) Navigational Astronomy, (2) Navigational Mathematics for the basic formulas used in celestial navigation, and; (3) Navigational triangle.

Celestial bodies are in constant motion; no fixed position in space from which one can observe absolute motion. Since all motion is relative, the position of an observer must be noted when discussing planetary motion. From the earth, apparent motions of celestial bodies on the celestial sphere are observed. In considering how planets follow their orbits around the sun, a hypothetical observer at some distant point in space is assumed. When discussing the rising or setting of a body on a local horizon, observer is located at a particular point on the earth because the setting sun for one observer may be the rising sun for another. Motion on the celestial sphere results from the motions in space of both the celestial body and the earth. Without special instruments, motions toward and away from the earth cannot be discerned.

On board, a mariner need a compass to know the North, South, West and East point of the horizon to direct his vessel to its destination. But to determine ones position using the sun and the star, a seafarer must also know its geographical position or its coordinates. This is essentially the point in studying the coordinate systems. Coordinate System in Celestial Navigation involves the Horizon and the Celestial Equator. Bowditch (1999) provides a comprehensive and technical detail on celestial navigation subject.

### 3 MAAPCNIA AS AN AID IN INSTRUCTION

Concepts in Celestial Navigation are mathematically oriented and complex. The key to total understanding this subject is comprehension of orthographic projection. However, students have difficulty in grasping and retaining tough three-dimensional information when presented using a one-dimensional space. Students are hard up in coping with the lessons because they are having difficulty in visualizing or imagining what is there to learn or to compute. Chances of failure in this subject is high because the very essential topic,

orthographic projection, in the mastery of this subject is not well appreciated and understood. This problem had led one of the senior maritime lecturers in the academy to devise an instrument that would improve teaching-and-learning processes in the class.

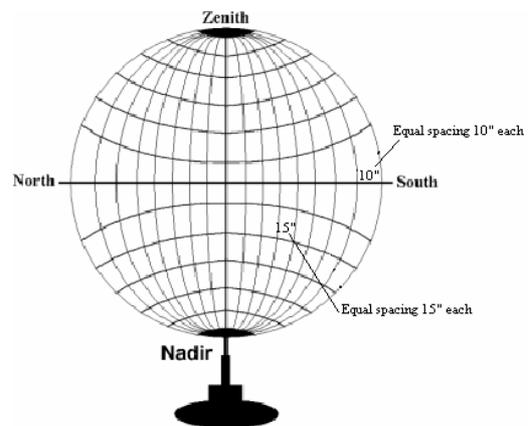


Fig. 1. Celestial Sphere

The instructional tool designed for teaching concepts of navigation is called MAAP Celestial Navigation Instructional Aid or MAAPCNIA. This was conceptualized and designed by Capt. Daniel S. Torres, Jr. in 2004 out of his passion and best intention to improve teaching methodologies and strategies, and enhance understanding and appreciation of the subject, thus preparing students to be competent deck officers in the future. With this tool, deck students can be able to gauge what they have learned in the lecture and show their progress through an interactive activity and feedback method. As one adage says *“What I can see and hear --- I can soon forget, but what I can do now with my hand is mine.”* The tool is so simple, versatile and inexpensive. Its construction only takes a week but its benefit in education is very substantial.

Essentially, the instructional aid is useful in teaching concepts of celestial spheres. Celestial sphere is an imaginary sphere of infinite radius concentric with the earth, on which all celestial bodies except the earth are imagined to be projected. The North and South celestial poles of this sphere are located by extension of the earth’s axis. The celestial equator is formed by projecting the plane of the earth’s equator to the celestial sphere. The celestial meridian is formed by the intersection of the plane of a terrestrial meridian and the celestial sphere. It is the arc of a great circle through the poles of the celestial sphere. The point of the celestial sphere vertically overhead of an observer is the zenith, and the point on the opposite side of the sphere vertically below him is the nadir. The zenith and nadir are the extremities of a diameter of the celestial sphere through the observer and the

common center of the earth and the celestial sphere (Figure 1).

There are two major parts of the instructional tool: the blue Celestial Sphere (Figure 2) and the white Celestial Sphere enclosing a globe in its center (Figure 3). Using the blue sphere, topics about the Horizon system of coordinates such as Zenith, Nadir, Altitude, Zenith distance, Azimuth, Point on the horizon, Prime vertical circle, Principal vertical circle, Vertical circles, and Altitude circle or parallel of altitude are easily conveyed to the students. On the other hand, with the use of the white sphere, Time Diagram, Celestial Equator system of coordinates, and Terrestrial System of coordinates are better communicated with the students compared with just using one-dimensional drawings of spheres. Lessons on Time Diagram include Hour circles, LHA, GHA, SHA, RA, Meridian angle, Meridian passage, and Longitude); on Celestial Equator system of coordinates involve Hour circle, GHA, LHA, Meridian angle, Declination, Polar distance, Diurnal circle or parallel of declination, Nocturnal arc, Celestial poles and Celestial equator, and; on Terrestrial System of coordinates are Terrestrial poles, Equator, Meridians, Greenwich meridian, Geographical position of the body, and the equivalence of the its components to the celestial system's components. Eventually, the blue and white spheres are combined to illustrate concepts of Meridian passage, Circumpolar bodies, Polar distance, Zenith distance, Co-latitude, and finally the composition of the Navigational Triangle. See Figure 4.



Fig. 2. Blue Celestial Sphere



Fig. 3. White Celestial Sphere with Globe at its Center



Fig. 4. Combined Blue and White Celestial Spheres

#### 4 TEACHING USING THE MAAPCNIA

The use of MAAPCNIA is anchored on the concept of authentic instruction. Newmann & Wehlage (1992) identified five (5) standards of authentic instruction which include the following: (1) higher-order thinking; (2) depth of knowledge; (3) connectedness to the world; (4) substantive conversation, and; (5) social support for student achievement. Using the instructional aid, instructors can better convey or communicate the lessons and ideas to their students. Likewise, the students can be able to easily grasp the lessons being taught. In the process, students are required to manipulate information and ideas, thus exercising higher-order thinking. The knowledge gained in the study of celestial spheres is not thin or superficial, rather is deep because students were able to easily visualize and understand the lessons. More activities and exercises can be handled because of improved teaching and learning processes. Students can readily picture what a one-dimensional drawing cannot show. Their experience in this subject demonstrates the five (5) standards of authentic instruction.

In teaching Time diagram or the Diagram on the plane of the celestial equator, students can use the white sphere with a globe inside together with a special stand so the sphere will lie horizontally. Looking from the South pole, an instructor can place a body and the sun according to its declination, the First point of Aries, the upper and lower branch of the meridian as well as the Greenwich meridian that coincides with the globe in the middle. From this, the students can readily determine the GHA, LHA, SHA, LMT, GMT, RA, longitude, and meridian angle just by counting the number of hour circles between them. (The sphere is divided into 36 equal semi-great circles =  $10^\circ$  each).

The Horizon system of Coordinates can be effectively taught by using the blue sphere. All components of the Horizon system can be touched such as the zenith, nadir, north, south, east and west point of the horizon, horizon, vertical circle, prime vertical, principal vertical circle, altitude circle, altitude, azimuth and the point on the horizon to determine the body's azimuth. Each component can be defined or described as you see and even touched it. In the end, the importance of the co-altitude or the zenith distance, which is one of the sides of the navigational triangle, can then be further emphasized. A colored tape is used to mark the zenith distance to emphasize its importance. This marked side is needed later on when the navigational triangle is constructed. While explaining these concepts to the students using the instructional tool, the instructor would also draw and discuss the exercise using orthographic projection on the white board so the students can really visualize the example. Right after discussing the horizon system of coordinates, the white sphere using the vertical stand is then used and explained. As shown, the white sphere is also divided into 36 equal meridians ( $10^\circ$  each spacing) and six (6) small circles from the equator to the poles ( $15^\circ$  apart). These spheres are just prototypes as these can also be divided into nine (9) if another spheres are to be constructed so they will be  $10^\circ$  apart and will be consistent with the meridians. The most important components to discuss with the white sphere is the hour circles, LHA, declination, parallel of declination or the diurnal circle, nocturnal circle, point on the celestial equator to determine the LHA and the co-declination or the polar distance. The instructor must emphasize the importance of the polar distance or co-declination as one of the side of the navigational triangle. In the meantime, those sides are marked using colored tape for later discussion. The exercise must also be drawn on the board using orthographic projection and must be thoroughly discussed.

Most celestial navigators reduce their celestial observations by solving a navigational triangle whose points are the elevated pole, the celestial body, and the zenith of the observer. The sides of the triangle are the polar distance of the body (codeclination), its zenith distance (coaltitude) and the polar distance of the zenith (colatitude of the observer). The navigational triangle is represented by the PZX. The PZ represents the co-latitude or the Celestial superimposed. The ZX represents the co-latitude or the Celestial Horizon. The PX on the other hand represents the co-declination or the celestial equator.

This can be shown using orthographic projection but the students had some difficulty in drawing the exercise. By combining the blue and white spheres (retaining the marked zenith distance and polar distance) the instructor should only align the North and South Pole of the white sphere with the local meridian on top. The elevated pole should also be aligned depending on the latitude of the observer. This will constitute the third and final side of the navigational triangle. In using the spheres, the students will see how a body will traverse the diurnal circle, will the body set (if circumpolar), will it pass the prime vertical, determine the azimuth during setting and rising, altitude and azimuth of the body at meridian passage, etc.

With these representations, the instructor could then provide a problem for the students to solve. For example, Z is the assumed position with latitude of  $15^\circ$  North and a longitude of  $120^\circ$  East. GP or geographical position of the body with the corresponding position on earth with latitude (declination) and Longitude (GHA Greenwich hour) can be computed.

## 5 IMPACT OF THE MAAPCNIA TO AUTHENTIC INSTRUCTION

In teaching concepts of celestial spheres, orthographic projection is extremely difficult to illustrate on a whiteboard, which is one-dimensional in nature. But with the use of the MAAPCNIA wherein students can observe spheres in a three-dimensional view, teaching and learning is enhanced. The instructional aid challenges the imagination of the students. The students can readily visualize the most common problems encountered by navigators involving the navigational triangle. These common problems, according to Bowditch (1995) are as follows:

1. For the reduction of a celestial observation to establish a line position (Given altitude, declination and meridian angle, find altitude and azimuth angle)

2. For the identification of an unknown celestial body (Given latitude, altitude and azimuth angle, find declination and meridian angle)
3. For finding azimuth when the altitude is known (Given meridian angle, declination and altitude to find azimuth angle).

The activities provided by the instructor using the MAAPCNIA had given the learners the visual and tactile feedbacks. Therefore, each activity is designed to gauge the progress of the learner as they are tasked to solve problems and explain. The instructor could present an example of the problem using the whiteboard vis-à-vis the instructional tool. Indeed, MAAPCNIA as a teaching instrument, supports the five (5) standards of authentic instruction:

(1) Higher-Order Thinking as students are required to manipulate information and ideas in ways that transform their meaning and implications such as when students combine facts and ideas in order to synthesize, generalize, explain, hypothesis or arrive at some conclusions or interpretation. Manipulating information and ideas through the use of MAAPCNIA and other processes allows students to solve problems and discover new meanings and understandings. When students engage in higher-order thinking, an element of uncertainty is introduced and instructional outcomes are not always predictable.

(2) High Depth Knowledge as the students can make clear distinctions, develop arguments, solve problems, construct explanations, and work with relatively complex understanding using the MAAPCNIA. Depth is produced in part, by covering fewer topics in systematic and connected ways. Using the MAAPCNIA, knowledge is deep as the teaching revolves around the central ideas of a topic on celestial navigation.

(3) High Connectedness to the World as the students work on problems or issues that the instructor and students see as connected to their personal experience or contemporary celestial navigational situations. The learners explore these connections in a way that create personal meaning and value beyond the instructional context.

(4) High Substantive Conversation as the students are provided the opportunity to share ideas, explain or ask questions using the MAAPCNIA and therefore resulting to coherent promotion of collective understanding of the topic on celestial navigation.

(5) High Social Support for Student Achievement as all students are included in the learning process. Using the MAAPCNIA, the instructor conveys his expectations for all students, including those that are necessary to master the challenging academic work in a climate where there is mutual respect. The

students with less skill or proficiency on the topics are treated in ways that encourage their efforts and value their contributions which is the essence of mutual respect.

The MAAPCNIA does not only appeal to the “*seeing*” sense of students of Celestial Navigation but also to their “*touching*” sense which could enhance their interest and retentivity of basic facts and principles, which are mere abstractions, in the subject. MAAPCNIA provides an authentic and constructivistic way of learning. Constructivistic, in a sense that the students are actively creating their own knowledge through a process of continually “*making sense*” of information and experiences and integrating new ideas with existing knowledge. This is based on the Theory of Constructivism stated by Huba & Freed (2000).

The MAAPCNIA, which is a convenient-size shrinkage of the actual thing, will enable students while engaged in the discourse during class instruction to understand and communicate at both detailed and “*big picture*” levels, and to acquire life long skills that permit continuous adaptation to workplaces that are in constant flux.

## 6 CONCLUSIONS

The MAAPCNIA provides an authentic and constructivistic way of introducing the basic principles, most especially in the computation of problems on celestial navigation. The results are accurate even at points near the conducting boundaries with less computational effort and with great understanding. Unlike the whiteboard and pen illustration, this teaching tool is made to provide a detailed map of the potential distribution of various celestial bodies and still be able to compute the problems with ease.

This is just a prototype of some sort and an improved version is still feasible. This would require a lot of simulations that need to be modified to study other particles interacting on other forces that may also add perturbation. Through studying the structures of various spheres and materials, one can then identify and classify a given problem, understand the reasons of its behaviors, and assess possible applications that might fit and suit to its exhibited properties. As a result, material development and improvement would then be favored as technology advancement through understanding of the basic concepts and principles on celestial navigation. In addition to this, it would be possible to manipulate a material through structure analyses and modifications; the MAAPCNIA could very well help on this concern. The basic power of visualization and manipulation

of the celestial bodies through the use of this teaching tool certainly had helped students to understand the true nature and laws that governs things surrounding the celestial bodies. Teachers and students who have used the MAAPCNIA provided similar feedbacks on their appreciation of the relevance and impact of said tool in the teaching and learning process. Indeed, the use of MAAPCNIA, engaged the students in using their mind well. This is a challenge in MET towards authentic instruction.

## 7 RECOMMENDATIONS

With the advent of automated position fixing and electronic charts, modern navigation is almost completely an electronic process. It would be a mistake if a mariner would be tempted to almost completely rely solely on electronic systems considering that electronic navigation systems are always subject to failure. Safety of the ship and the crew still always rely on the skills of the professional mariners. Hence, proficiency in conventional piloting and celestial navigation still remains very important. The instructional tool on celestial navigation would certainly teach the science of navigation in a manner that would be appreciated by students; however, the students must develop the art of navigation by experience. Students must use the necessary methods and techniques best suited to the vessel and the conditions at hand.

Further studies on the improvement of MAAPCNIA are recommended. Moreover, other innovations for educational development must be encouraged in MET.

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