High School (10th-12th grades)

MANU O KE ʻAINA – BIRDS OF THE LAND

How did Ancient Pacific Navigators use birds to judge distance and approximate location?

by Scott Allen Yago

Standard Benchmarks and Values:

Mathematics Common Core State Standards (CCSS):

- Geometry Circles G-C1: Prove that all circles are similar.
- Geometry Circles G-C2: Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

Nā Honua Mauli Ola (NHMO) Cultural Pathways:

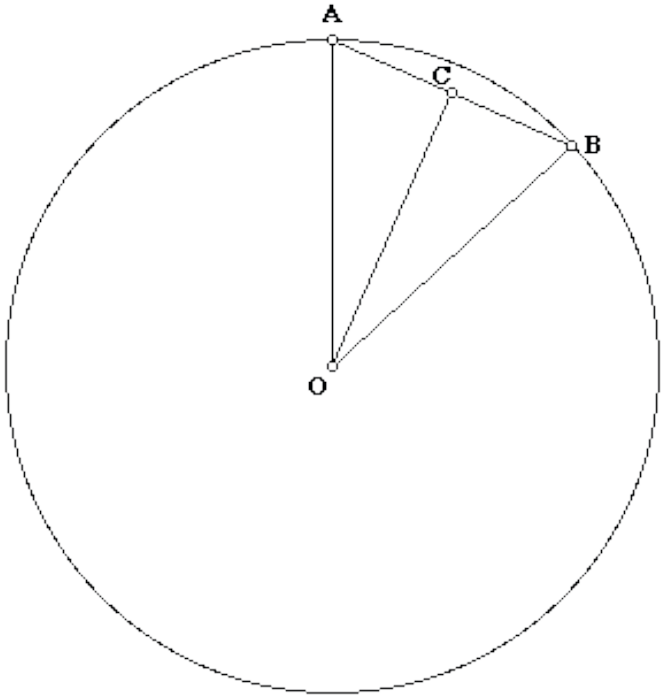
- ʻIke Mauli Lāhui (Cultural Identity Pathway): Perpetuating Native Hawaiian cultural identity through practices that strengthen knowledge of language, culture and genealogical connections to akua, ʻāina and kanaka.
- ʻIke Naʻauao (Intellectual Pathway): Fostering lifelong learning, curiosity and inquiry to nurture an innate desire to share knowledge and wisdom with others.

Enduring Understandings:

- Ancient Pacific Island navigation techniques are still in the process of rediscovery; using mathematics, find the connection that explains how techniques that ancient navigators used are relevant even in today's world.
- The navigation techniques are also still in danger of being lost this time.
- Certain land birds provide clues to finding islands and bearings.
- Not all birds are useful in finding land.

Background/Historical Context:

Ancient Pacific Island navigators used a multitude of techniques to find land and travel across vast oceans with accuracy and efficiency. One of those techniques included the use of two land birds to estimate the radius to locate land. The Manu O Ku is the white tern, and generally flies out 120 miles from land. This bird would be the first general marker in which one should try and follow in order to find land. Getting closer to land, the Noio (Brown Tern) generally flies 40 miles out from land.



Authentic Performance Task:

- Using geometrical properties of circles and knowledge about the two land birds, find bearings and distances to near shore islands using properties of circles.
- Understand and develop uses for circle proofs and theorems.
- Incorporate use of rates (e.g. If we've been traveling for 2 hours at 20 mph, how many miles have we traveled?).
- Integrate usage of right triangles and circles to find given bearings, distances, and angles within the triangle. (As an extension, incorporate trigonometric functions and their properties: SOH – CAH – TOA, to solve the triangle formed by the boats, and distance to land. This would include uses of SSA, SSS, SAS Triangles, and transition into trigonometry).

Authentic Audience:

Students, faculty and staff, teachers, and sailing instructors.

Manu O Ku (White Tern)

Noio (Brown Tern)

Learning Plan:

1. Introduce the history of Pacific Island navigators and a couple of techniques they applied in the open ocean.

2. Introduce circles and their general properties (e.g. radius, diameter, degrees, arc length, area, etc.).

3. After students become familiar with the circle, introduce the different theorems and delve into the specific properties of circles. Keep in mind, the most important part of this lesson stresses the use of chords and the perpendicular bisector.

4. Refresh the properties of a right triangle (angles, hypotenuse, Pythagorean Theorem).

5. Construct a problem or use the example in the worksheet.

6. Have the students divide into groups and perform group work.

7. Ask students, "After learning about the use of circles and triangles together, how can you apply these in real-world situations?" Have everyone give at least one example that they can think of and write a paragraph reflecting on the techniques of ancient Pacific Island navigators and geometry.

Standard Benchmarks, GLOs, or Nā Honua Mauli Ola	Skills	Concepts	Assessment
ʻIke Mauli Lāhui: Connecting ancient Pacific Island navigation techniques with geometry provides a good catalyst in seeing the relationship between ancient culture and modern techniques.	-Connect cultural techniques with geometrical theorems about circles. -Recognizing uses for ancient techniques in modern day society.	-Make students feel at home with the lesson. -Culture based math. -Provide a pleasant but challenging learning experience.	-The explanation of how Manu O Ku and Noio were used provide the culture based ideal in preserving and strengthening Native Knowledge. -The reflection question opens the students' minds to why culture strengthens what they've learned in class.
ʻIke Naʻauao – Analyzing techniques of Pacific Island navigation through geometry and other styles of mathematics.	-Interpret and explain learned content with individual opinions. -Ability to explain lesson to fellow peers.	-Engage students in critical thinking through real-world applications of mathematics. -Give students more choices in options towards their future education.	-The class question allows students to be more open towards their culture rather than feeling like they need to suppress it in the classroom.
G-C1: By using the perpendicular bisector, we can prove that all circles are similar. The perpendicular bisector allows the use of 2 points on a circle being used as a chord to find angles and distances within the circle. This can be applied in any circle.	-Use perpendicular bisector to solve for the distance between the point and the center (radius). -Use perpendicular bisector to find the center of the circle. -Use the perpendicular bisector to find distance between two chords.	-Use tangent and chords to solve distances from the center to a point on the circle. -Create a better understanding of the theorem. -Use tangents and chords to form right triangles within the circle.	-The attached worksheet provides problems that prove the perpendicular bisector and tangent line theorems. It also combines uses of algebra and an introduction to trigonometry. The worksheet is intended to combine topics of past math courses with geometry.

The overall goal for this lesson plan is to revive the ancient Pacific Island navigation techniques while breaking down the many reasons why they did work. Many children in today's Hawai'i are losing their connection to the culture and the land. It is very important for not only me, but also you to pass this knowledge on. Too reliant have we become on the ways of the modern world, lest we forget our roots and our native culture. By using an example that is non-Western, the material would feel much more at "home" and thus the students would be more likely to pick it up. This project is meant to intrigue the student and generate a sense of understanding of the subject, not just to learn it, but to apply it. Take your class out on the Hōkūleʻa or Hikianalia and point out the different uses of geometry and trigonometry in the real world; this would surely inspire and spark ideas in the minds of students.

Extensions: Trigonometry

• Because of the many mechanics in this navigation technique, it is quite possible to both break down and build up into a complex problem that would introduce uses of Trigonometry. By giving the students a radius (distance from you to the land), it creates a great medium to use and introduce calculations with sine, cosine, and tangent.

• Change the reference of the circle by making yourself the center and bringing the islands to you as in this picture (see references). From here, transition into bearings and navigational triangles (e.g. 60 degrees N of W).

References:

Manu O Ku - White Tern. (n.d.). Hawaii's Species of Greatest Conservation Need: Process and SGCN Fact Sheets. Retrieved June 18, 2013: www.state.hi.us/dlnr/dofaw/cwcs/files/NAAT%20final%20CWCS/Chapters/Terrestrial%20Fact%20Sheets/Seabirds/White%20fairy%20tern%20NAAT%20final%20!.pdf

Noio or Black Noddy. (n.d.). Hawaii's Species of Greatest Conservation Need: Process and SGCN Fact Sheets. Retrieved June 18, 2013, from http://www.state.hi.us/dlnr/dofaw/cwcs/Conservation_need.htm

Thompson, N. (n.d.). Hawaiian Voyaging Traditions. Retrieved June 18, 2013: http://pvs.kcc.hawaii.edu/ike/hookele/on_wayfinding.html