Mythologies of the Night Sky: An Experiential Learning Exploration of the Cosmos

Louie Elliott and Justin Michael Colvin
Mechanical Engineering, University of Tennessee at Chattanooga
Modern and Classical Languages and Literatures, University of Tennessee at Chattanooga

Abstract

This paper reports on a unique pilot course in the Honors Department at the University of Tennessee Chattanooga, UHON 3520: *Mythology of the Night Sky: A consilient tour through the Greco-Roman cosmos*, which explores ancient scientific and philosophical models of the cosmos. The lecture seminar explores focused topics through close, critical engagement with literary texts. Students will acquire skills in the analysis and interpretation of texts and deepen their knowledge of the ways in which figurative language contributes to human thought and expression. The laboratory seminar focuses on topics in scientific understanding of ancient astronomy methods. By participating in the systematic ways in which human beings analyze the physical universe, students will develop their abilities to gather and analyze data and understand the role of the natural sciences in human development. The paper discusses several novel pedagogical aspects of the course. In addition, we discuss modifications to make the content applicable to K-12 students.

Keywords

Ancient science, literature with a lab, mythology, astronomy, consilience

Overview

In the Fall Semester of AY 2020-2021, the authors team-taught a course through the Honors College of the University of Tennessee, Chattanooga [hereafter: "the University"]. The Honors College of the University solicits innovative, interdisciplinary courses from faculty throughout the university. The central conceit of the course was that the students and instructors would explore ancient astral ideation and reckoning through three principal source types: philosophical tracts, ancient 'scientific' treatises, and mythology. The authors were inspired to offer this course to dissolve the disciplinary walls that segregate the humanities from the sciences. While modern academic departmentalization facilitates revenue allocation, hiring practices, and funding streams, these divisions would have been insensible and unknown to the ancients. Only by tearing down the walls that divide us can we begin to approach what the ancients would have understood as their astral reckoning. Materials pertaining to ancient philosophy of the stars, ancient science on the stars, and ancient 'science' about the stars were thus each given pride of place as integral features of the course.

This offering was 'cross-listed' as a literature lecture course and a lab science course, a designation which vexed the University's registrar as no previous literature course had ever featured a lab requirement.

This course offered students the opportunity to enroll in one of two (but not both) curricular core requirements – 3520, a literature requirement, and 3565, a lab-science requirement. The learning outcomes for both enrollments were identical, and all students were expected to complete all work in kind regardless of their enrollment stream (i.e. there was no curricular distinction between the two enrollments).

Students who successfully completed the course earned four credit hours; those students enrolled to satisfy the literature curricular requirement (3520) enrolled in a 'dummy' section of UHON 1999r, a placeholder registration worth one credit hour, in order to rectify the credit-hour differential between 3520 (worth three credit hours) and 3565 (worth four credit hours). The course met for lecture twice every week, Tuesday and Thursday between 9:25am and 10:40am, and met for lab once every week, Friday between 4:00pm and 6:00pm. The modality of the course was hybrid in observance of the occupancy constraints presented by the ongoing COVID-19 pandemic, and students were given the option to attend both lecture and lab remotely, facilitated by means of a ZOOM® classroom furnished by the University.

Pursuant to the 'Statement of Instructor Responsibilities' outlined on the course syllabus, Professor Justin Michael Colvin who enjoys a joint appointment in the University's Departments of Modern and Classical Languages and Literatures and the Honors College, led the literature, philosophy, and ancient science portion of the lecture meetings. Dr. Louie Elliott in the Department of Mechanical Engineering designed and led the fabrication and explication of ancient scientific devices that the students crafted in lab. Student data was collected outside of lab meeting times.

The class yielded an enrollment of fourteen students out of a curricular cap of sixteen students. The literature curricular stream (3520) attracted two enrollments. These students, both juniors, are majors in a humanities department elsewhere in the University. The lab science curricular stream (3565) attracted twelve enrollments. These students, ranged in academic rank from sophomores to seniors (four of each), are majors in a variety of academic departments elsewhere in the University, but only two are majors in the so-called 'hard sciences'. Thus, the course presented an opportunity for humanities majors to collect a lab science requirement and lab science majors to collect a humanities requirement by satisfying identical learning outcomes and participating in the same learning activities.

Offering this course in the Fall of AY 2020-2021 presented some unique challenges owing to the ongoing COVID-19 pandemic. While the lab section of the course was originally intended to convene at the University's Clarence T. Jones Observatory and Planetarium, social-distancing restrictions rendered that intention impossible. Moreover, the lecture hall allocated to the authors by facilities presented novel challenges with respect to lecturing, as acoustics were difficult to manage in the booming, glass-clad hall (we mitigated this challenge using a microphone). Finally, students' observation of social-distancing and masking protocols presented some modification to student behavior but did not seriously impact student learning.

Lecture

The lecture portion of the course was designed by the authors to facilitate student familiarity with the ancient philosophical, ancient 'scientific,' and ancient mythological approaches to astral reckoning. Students were to have prepared in advance assigned readings – some derived from physical books required for purchase and some provided *gratis* in .pdf form on the course's online presence, facilitated by Canvas®. Students were expected, on average, to complete about 75-100pp. of reading every week, divvied out into two installments. No advance readings were required of the lab component.

Weeks one and two were devoted to considerations of mythology. Students were presented with a number of modern approaches to mythology in Robert A. Segal's *Mythology: A very short introduction*.[1] Students were also called to consider how ancients regarded their myths: the moral dangers of myth were explored in the (meager) surviving writings of the Presocratics, especially Xenophanes and Theagenes; the formal study of myth was explored in the (substantial) surviving writings of Post-Socratic philosophers, namely Plato and Aristotle; the 'rationalist' approach to myth was presented in the (ample) surviving writings of, among others, Palaephatus and Euhemerus.

Weeks three and four were devoted to establishing a *corpus* of ancient cosmogonic (e.g. the formation of the cosmos) myths derived principally from Apollodorus[2] and Ovid.[3] Beginning in week three, students were introduced to the 'philosophical' approach to ancient cosmology, at which time they read Plato's *Timaeus*[4] and Aristotle's *De caelo*.[5] Here we also encountered Hesiod's *Theogony*,[6] and established a cosmogonic and cosmological baseline against which to read subsequent contributions to ancient astral reckoning. Weeks five and six were devoted to exploring ancient notions of time and calendrical praxis. The students read Hesiod's *Works and days*[7] and Ovid's *Fasti*.[8] Having established the cosmogonic myths of the ancients and advanced theories of time and progression in ancient thought, the students were provisioned to consider the ancient mythology that accreted around the forty-eight Ptolemaic constellations.

Weeks six through twelve were devoted to considering constellation mythology – the stories that lay behind the Greco-Roman constellations – breaking these forty-eight constellations into smaller 'cycles.' (Admittedly, this construct was artificial and advanced owing to pedagogical exigencies and does not reflect any identifiable ideation surviving from the ancients.) Students were tasked with reading the constellation myths of pseudo-Eratosthenes, Hyginus, and Aratus collected and presented in parallel by Robin Hard's translation in *Constellation myths*.[9] Alongside the mythological account of the Ptolemaic constellations, students were required to read ancient 'scientific' treatises by Geminos,[10] Manilius,[11] and Ptolemy.[12]

Weeks thirteen and fourteen were given over to a sustained consideration of the Antikythera Mechanism, an ancient 'computer' that could accurately predict the position of celestial bodies and foretell eclipses. Students were required to read Alexander Jones' recent groundbreaking interpretation of the history and function of the device and consider the technical mastery that the device displays.[13] Students also considered the ancient phenomenon of *apotheosis* – or, 'deification' – that certain important figures, like Aeneas, Romulus, and Caesar, were believed to have undergone.

There were two deliverable assessments for the lecture component of the course. First, students were expected to complete a weekly writing assignment called the *scribendum*. Each Thursday, a new prompt and submission portal opened on the course Canvas that tasked the students with considering carefully and deliberating upon a given problem voiced by that week's assigned readings. Usually, these prompts focused the students on considering some or another aspect of Greek or Roman culture as it relates to the astral mythology presented in the week's readings. The following is a representative scribendum (week 10):

> *Compare and contrast the careers of Heracles and Perseus. How are their various brands of heroism consonant? How do they differ with respect to their heroism?*

The rubric required that a scribendum should be between 500 and 750 words and evince a clear command of the materials that can be gained only by reading, and must include: an argument, evidence from the reading, a citation of any text used, and clear and concise academic prose.

Second, students were given the option of giving three presentations on individual constellations and the myths that accreted around them, or of writing a final paper on Plutarch's "On the apparent face in the orb of the moon,"[14] a work collected into his *Moralia*. Twelve students opted for the presentations and two students opted to write a final paper.

Lab Seminar

The lab portion of the class focused on fabrication of ancient astronomy devices (the gnomon, sighting tube, and dioptra) as well as their usage including data collection and analysis. The final three labs were on topics to bridge the gap between ancient cosmogony and modern astronomy. These labs introduced the concepts of a helio-centric solar system, the life cycle of stars, and the expanding universe.

<u>Math Assessment</u>

The first activity of the semester was to perform a pretest assessment of the students' math proficiencies. The test was given without any foreknowledge by the students. The exam was fill in the blank as opposed to multiple choice. No formulary was given, and calculators were not allowed, but the questions were designed to be done by hand. The students were given one hour to answer 45 questions on the following topics:

- Calculating integer, fraction, decimal, and exponent expressions
- Percent and decimal conversions
- Scientific and standard notation conversions
- Substituting and solving algebraic equations
- Calculating geometric properties

The results of our pilot course are shown in Table 1.

Average	75.2
Max	95.5
Min	55.5
Standard deviation	10.8

Table 1: Results of math assessment.

In addition, the students were asked to self-assess and report (on a scale of one to five) their own abilities in: 1) crafting and building, 2) taking measurements and recording data, and 3) writing scientific reports. The goal of this question was to aid in balanced group formation and dynamics. DUE TO COVID the students worked alone or at most in pairs.

Lab 1: The Gnomon

Topic: The students construct a simple gnomon to measure the position of the sun in the sky.
Background: ancient cosmos models, celestial sphere, celestial equator, ecliptic, altitude, azimuth, magnetic and true north, right triangle trigonometry (angle calculation).
Materials: board, large flat head nail, sheet of paper, pencil, ruler, tape, and compass.
Data Collection: shadow plot.
Analysis: sun altitude, local noon, true north.

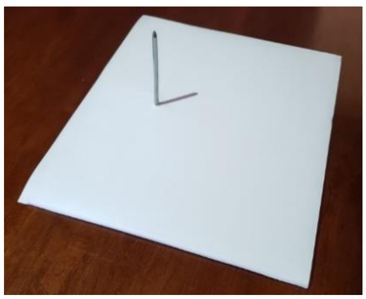

Figure 1: Constructed gnomon.

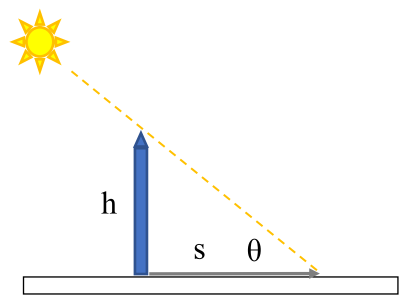

Figure 2: Sun altitude geometry.

$$\theta = tan^{-1}(h/s) \quad (1)$$

Lab 2: The Dioptra

Topic: The students construct a simple dioptra to measure the height of a wall.
Background: ancient surveying techniques, right triangle trigonometry (side calculation).
Materials: cardboard tube, protractor, nail, pen, ruler, and yardstick.
Data Collection: height of brick and number of bricks (method 1), angle to top of wall (three times, average) and distance to wall (method 2).
Analysis: height of wall (two methods).

Figure 3: Constructed dioptra.

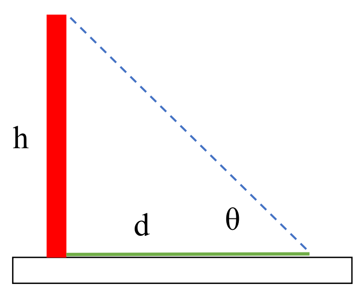

Figure 4: Wall height geometry.

$$h = tan\,\theta * d \quad (2)$$

Lab 3: Sky Journal

Topic: The students keep a sky journal of observations for a month.
Background: the Moon, phases of the Moon, the planets, stars, zodiac constellations.
Materials: a journal.
Data Collection: Sun shadow plot (lab 2), altitude and azimuth of Moon, phases of Moon, constellations, planets, others.
Analysis: compare shadow plots, determine phases of Moon, recognize constellations.

Lab 4: Size and Distance

Topic: The students calculate the size of the Earth and the size of the Moon.
Background: Earth/Sun geometry, parallax, Earth/Moon geometry, circumference and angle calculations, percent error.
Data Collection: supplied data.
Analysis: circumference of Earth (two methods), angular size of Moon, percent error from true accepted values.

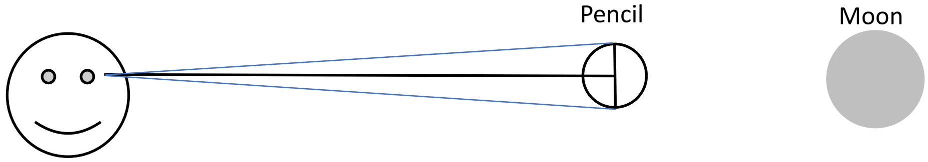

Figure 5: Moon angular size geometry.

$$\%_{error} = \frac{|Value_{true} - Value_{exp}|}{Value_{true}} \times 100 \quad (3)$$

Lab 5: Dioptra Azimuth

Topic: The students construct a base for the dioptra sighting tube for azimuth measurements.
Background: celestial sphere, altitude, azimuth, zenith.
Materials: foam board, drawing compass, protractor, pencil, and ruler.
Data Collection: two measurements of the altitude and azimuth of the Sun and Moon.
Analysis: compare to true values.

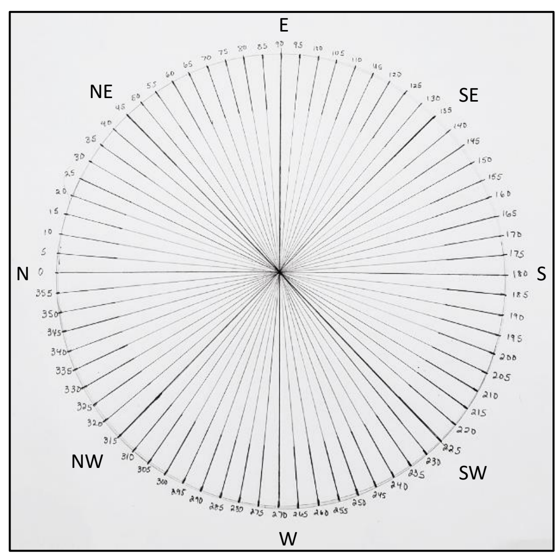

Figure 6: Constructed dioptra base for azimuth measurements.

Lab 6: Dioptra Final Combine

Topic: The students combine their sighting tube and base to complete the dioptra, and they determine the angular size of a constellation.
Background: dioptra, constellations, bounding box, angle area calculations, percent error.
Materials: dioptra base, cardboard tube, protractor, nail, 6 inch hex bolt (1/4 inch diameter), three 1/4 inch nuts, 5/16 inch washer, four 1/2 inch screws, and two hole metal straps.
Data Collection: altitude top and bottom and azimuth left and right for two constellations.
Analysis: angular area of constellations, percent error from true values.

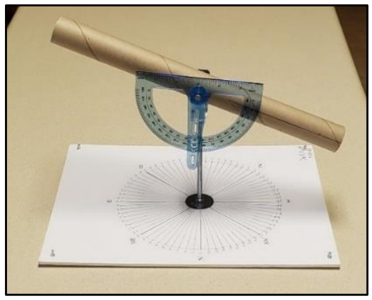

Figure 7: Final constructed dioptra.

Lab 7: Astrology – Pseudoscience?

Topic: The students generate a horoscope personality and psychological analysis from the internet and self-evaluate the truth of the statements.
Background: ancient and modern astrology, pseudoscience.
Data Collection: using time, location, and date of birth, the students use a website to generate the data.
Analysis: correlation factor.

Correlation Factor Range	Variable Relationship
$-1 <= \rho < -2/3$	Strong anti-correlation
$-2/3 <= \rho < -1/3$	Weak anti-correlation
$-1/3 <= \rho <= 1/3$	No correlation
$1/3 < \rho <= 2/3$	Weak correlation
$2/3 < \rho <= 1$	Strong correlation

Table 2: Correlation factor and variable relationship

Lab 8: A Heliocentric Solar System

Topic: The students verify Kepler's 3rd law.
Background: Geocentric and Heliocentric models, Kepler's Laws of Planetary Motion, Newton's Law of Gravitation, plotting data, trendlines.
Data Collection: (given) semi-major axis of orbit and orbital period for eight planets.
Analysis: compute and plot a^3 vs. T^2 for all, determine slope of trendline, compare to accepted value, and calculate the mass of the Sun, compare to accepted value.

Lab 9: The Life and Death of a Star

Topic: The students generate a Hertzsprung-Russell diagram.
Background: stellar evolution, Hertzsprung-Russell diagrams, main sequence, giant stars, dwarf stars.
Data Collection: (given) absolute magnitude and temperature of 40 stars.
Analysis: plot absolute magnitude vs. temperature for all stars, identify the main sequence, identify giant and dwarf stars.

Lab 10: An Expanding Universe

Topic: The students generate a Hubble diagram.
Background: Doppler effect, redshift, spectral lines, Hubble diagrams.
Data Collection: (given) distance and K line wavelength for 10 galaxies.
Analysis: compute redshift and recessional velocities, plot velocity vs. distance, determine slope of trendline (Hubble constant), compare to accepted value, and calculate age of universe, compare to accepted value.

Adaption

The central conceit of this course – that literature can be pressed into the service of teaching astronomical concepts – allows it to be adapted to K-12 pedagogy easily. Three pedagogical orientations and three learning outcomes are particularly relevant:

Pedagogical orientations:

- Reading mythology is an activity already familiar to many young people. Understanding that a whole genre of myths – called *catasterisms* – deal with images believed to be seen in the sky – i.e., constellations – allows one to lead into the other. Thus, reading astral mythology can be a 'Trojan Horse' for learning astronomical concepts.
- Ancient 'science' was paradoxically both sophisticated and rudimentary, simultaneously. What the ancients were able to achieve with respect to astral reckoning, as long as their faulty cosmology can be bracketed, is astonishing. However, their instrumentation was simplistic enough that many items can be fashioned by young people today.
- Understanding ancient cosmology as a transdisciplinary enterprise simply underscores the constructed nature of our own, modern disciplinary regime. The ancients would not have profitably distinguished between philosophy, 'science,' and mythology, and a student need not either. Viewing scholarship as holistic prepares young people to think in inter- and transdisciplinary terms.

These pedagogical orientations naturally flow into three related learning outcomes:

- Basic, bare-eye astronomy: Learning to appreciate the heavens;
- Rudimentary astronomical reckoning: Learning to take cosmological data;
- Elementary maths: Learning to manipulate those data mathematically.

The central tenet of this presentation has been to maintain that literature can be pressed into the service of learning basic astronomical concepts. Such adoption would encourage students' enthusiasm for learning about the cosmos and work with the wonder already present when beholding the night sky.

References

1 Robert A. Segal, *Mythology: A very short introduction*, 2nd ed. (Oxford, 2015).
2 Apollodorus, Library of Greek mythology, Robin Hard, tr. (Oxford, 2008).
3 Ovid, Metamorphoses, A.D. Melville, tr. (Oxford, 2009).
4 Plato, Timaeus, Donald J. Zeyl, tr. (Hackett, 2000).
5 Aristotle, De caelo, C.D.C. Reeve, tr. (Hackett, 2020).
6 Hesiod and Theognis, Theogony, Works and days, and Elegies, Dorothy Wender, tr. (Penguin, 1976).
7 Hesiod, op. cit.
8 Ovid, Fasti, Anne and Peter Wiseman, trs. (Oxford, 2013).
9 Eratosthenes, Hyginus, and Aratus, Constellation myths, Robin Hard, tr. (Oxford, 2015).
10 Geminos, Introduction to the Phenomena, James Evans and J. Lennart Berggren, trs. (Princeton, 2007).
11 Manilius, Astronomica, G.P. Goold, tr., LCL 469 (Harvard, 1977).
12 Ptolemy, Almagest, G.J. Toomer, tr. (Duckworth, 1984); Ptolemy, Tetrabiblos, F.E. Robbins, tr., LCL 435 (Harvard, 1940).
13 Alexander Jones, A portable cosmos (Oxford, 2019).
14 Plutarch, Moralia, Volume XII, Harold Cherniss and W.C. Hembold, trs., LCL 406 (Harvard, 1957).

Louie Elliott

Louie is an Assistant Professor in the Mechanical Engineering Department at the University of Tennessee at Chattanooga with degrees in physics and computational engineering. His primary research interest is the simulation and modeling of complex systems with a focus on numerical design optimization. Louie accumulated 10 years of industry experience in sensor design, prototype development, electromagnetics, and fuel cell simulations. He performs funded research with students in additive manufacturing and sheet metal forming as well as outreach programs with local middle and high schools. He is currently Secretary of the K-12 division for the ASEE Southeastern section.

Justin Michael Colvin

Justin Michael Colvin specializes in ethnic ideation, the reckoning of community, and the formation of identity in the late-antique and early-medieval Latin west. He has taught courses on historiography in antiquity, post-Roman receptions of Roman political thinking, the barbarian migrations of late antiquity, three courses on the uses of modern scientific methodologies to the student of the premodern past (consilience history), and a course on the perception of skin color in antiquity and late antiquity. He earned his BA, *magna cum laude*, from Columbia University in History (hons.) and Religion (hons.) and his MA at Fordham University in History.