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Our Moon: A Multidisciplinary Course to Develop Students' Interest

—Viranga Perera

Assistant Professor of Instruction, Physics Department, University of Texas at Austin.

Correspondence concerning this article should be addressed to: vperera@utexas.edu

Abstract

It is important for educators to help students develop interest in a topic so that they are driven by that interest to learn. With that as a primary goal, I designed and taught an undergraduate course that introduced students to the Moon from a multidisciplinary perspective. The *Our Moon: From Imagination to Exploration* course involved active lectures and projects designed by students. Here I discuss how I planned and implemented the course based on an interest framework. I give examples of lecture content covered in the course as well as examples of student projects. I believe that students at different colleges and universities will find this course interesting and I encourage educators to improve and teach the course at their institutions. It will be important to conduct research in the future to gauge changes in student interest pertaining to the Moon as a result of them taking this course.

Keywords

The Moon, interest, multidisciplinary, undergraduate, course design

When I got the opportunity to teach an undergraduate course about the Moon at Johns Hopkins University in fall of 2019, I was quite excited because I am rather fond of the Moon. I think that enthusiasm started when I saw the movie *Apollo 13* as a child. That "successful failure" triggered an interest that later led me to completing a bachelor's degree in aerospace engineering and then to graduate school where I studied the early geophysical evolution of the Moon. By teaching the *Our Moon: From Imagination to Exploration* course, I wanted to not only convey my fascination with the Moon to students, but also to invite them to discover an aspect of the Moon that was interesting to them. In this article I document the philosophy and design behind the course, so that instructors who are interested can improve and teach the *Our Moon* course to their students.

Course Planning

As I was planning the course in summer 2019, at the time, it was also fittingly the 50th anniversary of the Apollo 11 mission. Since I was introduced to the Moon by the retelling of Apollo stories, it was a good opportunity for me to reflect not only on the Apollo program but also to think generally about the Moon. I thought about questions like: What should a course about the Moon cover? Who was the course for? Do students even care about the Moon? The name of the course, *Our Moon: From Imagination to Exploration*, hints at answers to those questions.

Recent work by Flaherty et al. (2017) and Kulkarni and Vinuales (2020) presented preliminary evidence that non-traditional course titles can positively affect students' interests in taking a course. I wanted the course title to indicate both the topics that would be covered and the intended audience for the course. The "our" in

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the course title pointed to a sense of common heritage since the Moon has meaning to numerous cultures from around the world (e.g., Loske & Massey, 2018). I wanted the course to be inviting for a diverse group of undergraduate students. Additionally, "from imagination to exploration" in the title indicated that the course was multidisciplinary (the course sequence with topics that were covered are listed in **Table 1**). I believed that a multidisciplinary approach would help accomplish the learning objective of the course, which was that each student would find and learn about at least one aspect about the Moon that was interesting to them.

Table 1

Course sequence

Topics	Disciplines	Details
Mythology & Religion	Mythology & Religion	Myths pertaining to the Moon from different cultures. Lunar calendar in relation to religious holidays. Religious observations by Apollo astronauts.
"Earthrise"	History & Literature	The Apollo 8 "Earthrise" picture in relation to Lucian of Samosata's *A True Story* and *Icaromenippus*, along with historical events of 1968 (e.g., the Vietnam War and the Civil Rights movement).
Lunar Data	Aerospace Engineering & Planetary Science	Guest lecture by Michael Pryzby. Lunar data exploration with Arizona State University's QuickMap (http://quickmap.lroc.asu.edu/).
Evolution of the Moon	Planetary Science	Apollo samples, theories of Moon formation, and the Lunar Magma Ocean.
Rocket Science	Aerospace Engineering	History and types of rockets, V-2 rockets in World War II, development of the Saturn rockets, and rocket design.
Cold War/ Space Race	History, Politics & Aerospace Engineering	Historical events from the end of World War II through the end of the Space Race with a particular focus on individuals and significant achievements in space flight.
Who Owns the Moon?	Politics	Five United Nations space treaties, connections to international waters and the Law of the Sea (1994), along with the Antarctic Treaty System.
The Moon in Cinema	Movies	Clips from nonfiction and fiction films showing how the Moon is depicted over time.
The Moon in Literature	Literature & Planetary Science	*De la Terre à la Lune (From the Earth to the Moon)* by Jules Verne with connections to lunar science and the Apollo program.
Future Exploration	Planetary Science & Aerospace Engineering	Discovery and presence of water on the Moon with how it may be extracted during future human exploration of the Moon.

Course Implementation

The *Our Moon* course was supported by the Zanvyl Krieger School Science Teaching Postdoctoral Fellow Program at Johns Hopkins University**.** The program encourages postdoctoral researchers to propose and teach a course for undergraduate students. Since the *Our Moon* course was new, it was not part of a degree program, but it had the designation of a Krieger School of Arts and Sciences course. As the course was open to all students, there were no prerequisites. The course was offered in the Fall 2019 semester for 3 credits and consisted of two sections. Each section of the course met twice a week for 75 minutes.

I wanted the course to be open to all students and advertised the course widely by sending emails to various department offices and by posting flyers around the campus. One section of the course had 5 students, while the other had 14 students. Students who enrolled in the course ranged from 1st to 4th-year undergraduates, along with one graduate student (who audited the course). Students' academic majors were diverse and broadly represented academic disciplines including the humanities (e.g., English and history), social sciences (e.g., economics, international studies, and public health studies), natural sciences (e.g., cognitive science, environmental science, and physics), applied sciences (e.g., chemical & biomolecular engineering and mechanical engineering), and mathematics.

In addition to welcoming students of different academic backgrounds to the course, I also wanted to make the course accessible as much as possible. To keep the course costs low, I did not assign a course textbook.

Additionally, I made the primary course material (i.e., lectures) freely available on the course website (https://ourmoon.space/lectures) as PowerPoint slides (with notes), narrated YouTube videos, and audio recordings. By making the lectures available in multiple formats, I hoped to make them accessible for those who may have certain disabilities and to allow students to review course material in a format that they preferred. In addition to the course lectures, the course website also pointed students to additional online resources, so that they could continue their exploration of topics that they found particularly interesting. Furthermore, the continued availability of the course material on the course website means that even those who did not take the first iteration of the course can still use the website to asynchronously learn about the Moon on their own.

Interest Framework

The fact that interest is vital to learning has been discussed for decades (e.g., Hidi, 1990; Ainley et al., 2002; Harackiewicz & Hulleman, 2010; van der Hoeven Kraft, 2017). Nevertheless, many of us are still very familiar with 'eat your broccoli because it is good for you' courses where we are told by an instructor to care about something since the topic is "interesting." My own interest could have naturally led me to teaching the course in such a pontificating manner. Rather, knowing that interest is subjective, I wanted to invite students to find aspects about the Moon that were interesting to them. In this work, I adopted the definition of *interest* from Renninger and Su (2019) as both "the psychological state of learners during their engagement with particular content (e.g., communication, mathematics, basketball) and…their motivation to continue to reengage that content over time." For the purpose of pedagogy, it is important to note that interest can be developed (e.g., Hidi & Renninger, 2006; Renninger & Su, 2019) and that instructors can have a significant influence on helping students develop interest (Rotgans & Schmidt, 2011).

In regard to multidisciplinary courses, there is evidence that they can aid interest development among students. For example, Near and Martin (2007) designed an undergraduate course about psychoactive drugs from a multidisciplinary perspective (i.e., chemistry, ethics, genetics, law, pharmacology, psychology, and sociology). Their course evaluations showed that students reported an increased interest in the subject. More recently, Griswold (2017) taught a multidisciplinary undergraduate course about climate change. Half of the students who took that course reported that they either had a new interest in science or an ongoing interest. While we need additional research, preliminary evidence suggests that multidisciplinary courses can help with interest development.

For the *Our Moon* course, I used the Four-Phase Model of Interest Development as the theoretical framework (Hidi & Renninger, 2006). In their work, Hidi and Renninger divided interest into four phases: *Triggered Situational Interest*, *Maintained Situational Interest*, *Emerging Individual Interest*, and *Well-Developed Individual Interest*. They argue that interest is 'trigged' by a specific situation (e.g., a classroom activity) and can develop over time to a persistent individual interest (e.g., a hobby).

The aim of the course was to help create situational interest (both triggered and maintained) with the hope that at least some students would further develop individual interest after the course. I used multidisciplinary lectures to trigger situational interest (see Course Lectures) and I used assessments to help students maintain situational interest (see Course Assessments). I believe together these components of the course helped trigger and maintain situational interest among the students, but future research is necessary to be definitive.

Course Lectures

As mentioned earlier, course lectures were designed to trigger situational interest (e.g., Palmer, 2009) through a multidisciplinary discussion of topics pertaining to the Moon (see **Table 1**). While all lectures of the course are freely available on the course website (https://ourmoon.space/lectures), I will discuss a few topics in detail below so that the reader can appreciate the value of a multidisciplinary approach when discussing the Moon.

The Moon, Race, and Gender

Throughout the course I discussed people who are part of the story of the Moon. While some people, particularly from the Apollo era (e.g., Neil Armstrong and Buzz

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Aldrin), are still household names, contributions of "Hidden Figures" have only more recently been widely recognized (e.g., Shetterly, 2016; Birney et al., 2018; Aegerter et al., 2019). While I of course knew of John Glenn (first American to orbit the Earth) from a young age, it was only fairly recently that I learned about "Hidden Figures" like Katherine Johnson. Course discussions allowed students to consider both race and gender for a more complete picture of people who were involved in the story of the Moon.

Conversions about race and gender, and of course substantive societal changes, are essential and the history of the space program provides us with opportunities for discussions about these topics. For example, we discussed how just prior to his Mercury-Atlas 6 (Friendship 7) mission in 1962, Glenn reportedly asked "the girl" (Johnson) to check the numbers. Johnson was 43 years old at the time; Glenn was 40. Why did Glenn refer to Johnson as "the girl"? Moreover, when we discussed the subject of female astronauts, we considered Glenn's testimony during the special subcommittee meeting of the House Committee on Science and Astronautics in the United States Congress in July 1962. Glenn testified, "I think this gets back to the way our social order is organized really. It is just a fact. The men go off and fight the wars and fly the airplanes and come back and help design and build and test them. The fact that women are not in this field is a fact of our social order. It may be undesirable" (Weitekamp, 2005, p. 151). That "social order" meant that Jerrie Cobb (first female American aviator to pass all of the Mercury 7 physiological tests) never became an astronaut. When the first woman in space, Valentina Tereshkova, met Cobb she stated, "We always figured you would be first. What happened?" (Stone, 2009, p. 84). Perhaps what happened was that "social order" resulted in all 12 of the first humans to walk on the Moon being White men.

While people accomplished the astonishing task of building rockets that took humans a distance of 385,000 km (240,000 miles) to the Moon, that journey also involved discrimination based on race and gender. By making these connections, I hoped that students would be able to actively participate in future conversations about lunar exploration, so that we can encourage diverse groups of people to participate while trying to avoid repeating past failures.

The Moon and Politics

As part of the discussion about the begins of the Apollo program, I wanted students to understand the large part politics played in establishing the program. For one, while the story of the Apollo program is often told starting from when the Soviet Union launched the first satellite (Sputnik 1) on October 4th, 1957, it in fact should start much earlier with the end of World War II. Additionally, while some may think that president John F. Kennedy was a consistent advocate of the Apollo program, the reality is that his support waxed and waned. We discussed both of these aspects as part of the section on the Cold War.

Nazi scientists and engineers played a large role in the success of the Apollo program. Towards the end of World War II, the United States brought over a thousand Nazi scientists and engineers as part of Operation Paperclip. One of those engineers was of course Wernher Von Braun. He designed and developed V-2 missiles that likely killed tens of thousands of people (counting both deaths of concentration camp workers and those killed by missile attacks) (National Air and Space Museum, 2000). Von Braun would become the chief architect of the Saturn V rocket, which took Apollo astronauts to the Moon. His current biography on the NASA Marshall Space Flight Center website notes that he "was a member of the Nazi Party and an SS officer" and "his responsibility for the crimes connected to rocket production is controversial" (Marshall Space Flight Center, 2017). The connection of Nazi scientists and engineers to the Apollo program is a historical fact that is important for students to learn.

Another historical aspect that needs closer examination is Kennedy's plans for the Apollo program. Twenty days after Alan Shepard became the second man and the first American in space, Kennedy gave his famous speech to Congress on May 25th, 1961 where he said, "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the earth" (Kennedy, 1961). Retellings of the story of the Apollo program often go linearly from that speech through the various Apollo missions to the successful Apollo 11 landing. However, in actuality the history of the Apollo program is of course more involved. In fact, 10 days after his speech to Congress, in a summit in Vienna, Austria, Kennedy proposed a joint mission to the Moon to Soviet Union

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premier Nikita Khrushchev. Khrushchev declined the offer (National Aeronautics and Space Administration, 2002). The following year, on September 12th, 1962, Kennedy gave his "we choose to go to the Moon" speech at Rice University (National Aeronautics and Space Administration, 1962). However, nearly exactly a year later on September 18th, 1963, during a meeting with James Webb (then NASA Administrator), Kennedy stated, "I don't think the space program has much political positives…I mean if the Russians do some tremendous feat, then it would stimulate interest again, but right now space has lost a lot of its glamour" (Kennedy, 1963a). Two days later in his speech at the United Nations, Kennedy stated, "Why, therefore, should man's first flight to the Moon be a matter of national competition?" (Kennedy, 1963b). Were students to only know about Kennedy's "before this decade is out" and "we choose to go to the Moon" speeches, they would interpret his advocacy of the Apollo program very differently than if they learned about all these instances of Kennedy discussing the Apollo program.

It is important to help students learn about the complete (or a more complete) history of the Apollo program. They need to ponder questions like: What does a journey planned and implemented by someone like Von Braun say about our first trip to the Moon? What does it say about us? How do we interpret a president who gave a directive to go to the Moon and then changed his mind several times? Examples of Von Braun and Kennedy illustrate the complexity of how the Moon and politics are intertwined.

The Moon and Sense of Place

According to place-based education, making connections to *place* will help students develop interest and aid their learning (e.g., Leonard et al., 2016; Liebtag, 2018). A *place* can be defined as a "locality that people have imbued with meanings and personal attachments through actual or vicarious experiences" (Semken et al., 2017). Given our history, culture, and exploration, the Moon itself is a *place* to many people (see Messeri, 2016). Alternatively, another *place* for students is Baltimore, Maryland since the course took place in the city and many students were either from the area or lived there. As such, to connect course material to students' sense of place, I made several connections to Baltimore.

The first connection to Baltimore was during a discussion about the history of rockets. Congreve rockets were fired at Baltimore Harbor by British forces during the War of 1812 (National Park Service, 2002). It was that "rockets' red glare" that Francis Scott Key saw and served as inspiration for his poem *Defence of Fort M'Henry* (Key, 1814), which of course would later go onto become *the Star-Spangled Banner*, the American national anthem. The second connection to Baltimore was when students read the book *De la Terre à la Lune* (*From the Earth to the Moon*) by Jules Verne (Verne, 1865). The book is an important literary work regarding the Moon. Even Neil Armstrong acknowledged the book on the way back from the Moon during the Apollo 11 mission (National Aeronautics and Space Administration, 1969). The setting for Verne's story is Baltimore, Maryland and the premise is that the Baltimore Gun Club created weapons for the American Civil War (1861–1865), but at the end of the war they needed "another outlet for [their] restless energy." As such, the president of the club, Impey Barbicane, propose to lead them "in the conquest of the Moon." Much like how Barbicane's vessel traveled to the Moon from Florida, about 100 years after Verne's story, Apollo astronauts would also leave the launch site at Cape Canaveral, Florida to travel to the Moon.

Connecting the Moon to students' sense of place is beneficial to their learning. It may seem that instructors in places like Texas (location of the Apollo Mission Control Center) and Florida (location of the Apollo launch site) will find it much easier to connect the Moon to their geography. However, given that the Moon has global meaning to people, I believe it is possible for most instructors to connect the Moon to students' sense of place.

Course Assessments

As discussed previously, I devised course assessments to help students maintain situational interest. I used both formative and summative assessments during the course. Formative assessments primarily consisted of various activities that I asked students to work on as part of the lectures. Summative assessments consisted of three small projects and a final project. I discuss each assessment type in more detail below.

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Formative Assessments

I assigned formative assessments to make the lectures more active (e.g., Dixson & Worrell, 2016). Formative assessments were given during many of the lectures, but not every class period. When formative assessments were given, student had about 10 minutes to work on them. A few examples of formative assessments from the course include writing prompts (e.g., *What does the Moon mean to you?* & *Reflect on the Apollo 8 "Earthrise" picture*) and periods of time when students worked on their own (e.g., exploring a myth about the Moon that they found particularly interesting, putting phases of the Moon in the correct sequence, and trying to explain why the Moon goes through phases). After each formative assessment, I asked for volunteers to share with the class. These assessments allowed me to better structure subsequent lectures and to help students develop their own interests.

Summative Assessments

To help students maintain situational interest, I asked students to work on three small projects individually and I gave them the option of working on the final project in groups. At the beginning of the course, I instructed students that I did not want them to create "dumpster projects" (i.e., projects that are discarded after being graded) (Gibson, 2019). Since the projects were for them, they were asked to create something that they did not just "turn in," but were proud to keep after the course. Giving students more agency with choice is an educational practice that has been around for some time (e.g., Flowerday & Schraw, 2000). For example, in an ecology course where students designed their own experiments their "ownership of the projects carried over into high enthusiasm for conducting the research and writing about it" (Rettig & Smith, 2009). A meta-analysis by Patall et al. (2008) confirmed that choice has a positive effect on motivation, but they note caveats about having too many choices. Therefore, to provide some structure for students, for the small projects I asked that they turned in a short description of their planned project a few weeks prior to the project due date. That was done primarily to encourage students to think about their projects early and not wait till they were due to begin working on them. I read the project descriptions to make sure students proposed a project that fit the requirements and provided them with feedback as needed. In addition to the project itself, I asked students to do a brief presentation about their work to the class. I also asked them to work for at least 10 hours outside of class and to document their time with the expectation that they turned in their timesheet with their project. The final project was similar to the small projects, but I expected them to spend at least 20 hours outside of class on the final project. Students had the option of either further developing one of their small projects or coming up with an entirely new project. All projects were graded for completeness since, given the diversity of the types of projects that students created, it was not feasible nor beneficial for interest development for me to grade based on a predefined rubric. Each of the three small projects was worth 20 points and the final project was worth 40 points (the course grade was based on a total of 100 points). For the small projects, students received 2 points for the short description of their project, 15 points for the project itself, and 3 points for the brief presentation. Point allocations for the final project were twice as those of the small projects.

Students worked on a diverse range of projects that included musical recordings, computer codes, movie reviews, paintings, and short stories (see **Figure 1** for three examples of student projects). As noted in Course Planning, the learning objective of the course was for each student to find at least one aspect about the Moon that was interesting to them. Through their projects students demonstrated that they had maintained situational interest. For example, the *Apollo Program-Inspired Outfits* by Rachel Miller shown in **Figure 1** exhibits that Rachel took ideas presented in the course and applied it to their own interests. While the various Apollo missions were discussed during the course, I did not directly address how the Apollo program did, and in Rachel's case can still influence design (viz., fashion design). I was impressed with this project since it showed artistic interpretations of specific aspects of the Apollo program (i.e., launch of the Saturn V rocket, the Mare Tranquillitatis landscape, and Ken Mattingly being removed from the Apollo 13 mission). I encourage readers to find a more complete list of student projects on the course website at https://ourmoon.space/projects.

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Figure 1

Select student projects

Baking Mooncakes by Serena Tang**.** This project relates mythology and religion to the Moon. Mooncakes are prepared and eaten during the Mid-Autumn Festival, the timing for which is partly based on a full Moon.

Painting of the Moon by Andrea Schmidt. This painting was inspired by *Four Times of the Day: Night* (1757) by Claude Joseph Vernet.

Apollo Program-Inspired Outfits by Rachel Miller**.** From left to right: outfits inspired by the Saturn V rocket (bottom depicts the rocket exhaust), Apollo 1 mission (with astronaut last names Grissom, White, and Chaffee), Apollo 11 mission (depicting the lunar landscape), and Apollo 13 mission (sleeves with red dots for Ken Mattingly being removed from the mission due to being exposed to measles).

Discussion

Overall, I think the first iteration of the *Our Moon* course was a success. This course joins other multidisciplinary and interdisciplinary courses (e.g., *Water* [Tabbutt, 2000], *Law and Literature* [Schotland, 2009], *Physics and the Arts* [Dark & Hylton, 2018], and *Science and Culture of Blood* [Wolfson & Armstrong, 2020]) in presenting a topic from different perspectives while helping students to develop interest in a topic. While it is a limitation that I did not assess students' interest development through a research study, I have anecdotal evidence (e.g., Lightcap, 2009) from students' comments and reactions during the course that the course successfully promoted interest development. In a future iteration of the course, students' interest development can be better studied using survey and interview data.

While the first iteration of the course was taught from a multidisciplinary perspective, in a future iteration of the course I would like to develop it further as an interdisciplinary course. Newell and Green (1982) defined interdisciplinary "as inquiries which critically draw upon two or more disciplines and which lead to an integration of disciplinary insights." **Figure 2** shows a concept map as an example of further developing ideas of this course to better integrate between traditionally distinct disciplines (e.g., literature and aerospace engineering). The figure shows some of the topics that can be connected between Jules Verne's book *De la Terre à la Lune* (*From the Earth to the Moon*) and the Apollo 11 mission. For example, using animals to test spacecraft is mentioned in Verne's story and is a practice that was in fact essential to getting crewed spacecraft ready during the early days of the space program (e.g., Laika the dog and Ham the chimpanzee). I believe that a future interdisciplinary version of the *Our Moon* course would be even more beneficial to students.

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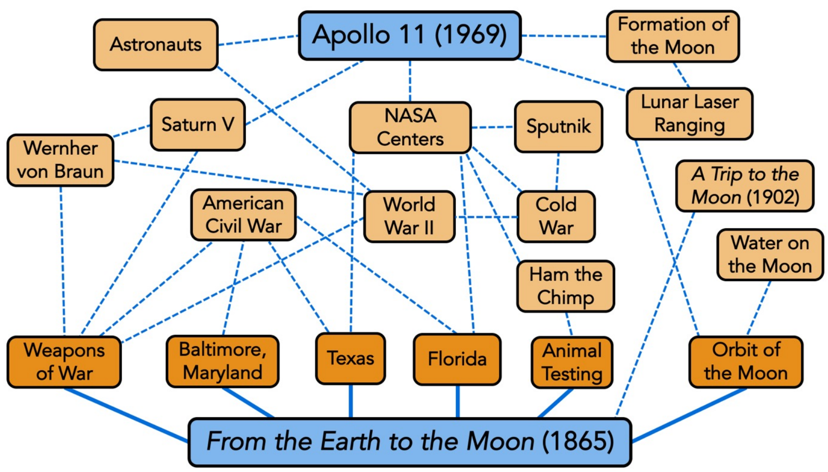
Figure 2:

Example concept map of topics based on Jules Verne's book De la Terre à la Lune (From the Earth to the Moon)



Plutarch is credited with saying, "the correct analogy for the mind is not a vessel that needs filling, but wood that needs igniting" and that philosophy is central to the *Our Moon* course where the goal was to develop students' interest of the Moon by presenting course material from a multidisciplinary perspective. Additionally, giving students agency to create projects that they found personally meaningful further supported interest development. The Moon is our common heritage. It is in fact *our* Moon. My hope is that the first iteration of the *Our Moon* course (and hopefully subsequent versions of it) will generate individual interest in a diverse group of students, so that they can be active participants in the future exploration of the Moon. Ex luna, scientia.

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