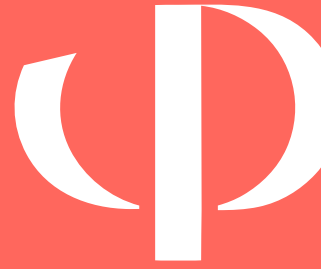


# Teaching Philosophy



FALL 2025

VOLUME 25 | NUMBER 1

## LETTER FROM THE EDITORS

Tziporah Kasachkoff and Eugene Kelly

## SUBMISSION GUIDELINES

## ARTICLE

Serife Tekin and Chris Packham

*The Philosophy of Space Exploration (PoSE): An Immersive Course to Explore and Inspire Next Generation Ethical Considerations*

## LIST OF CONTRIBUTORS



APA STUDIES ON

# Teaching Philosophy

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TZIPORAH KASACHKOFF AND EUGENE KELLY, CO-EDITORS

VOLUME 25 | NUMBER 1 | FALL 2025

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## LETTER FROM THE EDITORS

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We welcome our readers to the fall 2025 edition of the *APA APA Studies in the Teaching of Philosophy* (formerly the *APA Newsletter on Teaching Philosophy*). We offer in this edition one article, "The Philosophy of Space Exploration (PoSE): An Immersive Course to Explore and Inspire Next Generation Ethical Considerations." The authors of the article are Serife Tekin, of the Center for Bioethics and Humanities, SUNY Upstate Medical University, and Chris Packham, of the Department of Physics and Astronomy, University of Texas at San Antonio.

The title of the paper initially surprised some of its readers: How could developments in space exploration give rise to unique questions of a *philosophical* sort? To be sure, earlier adventures in exploration can be seen to have raised not only philosophical quandaries but also specific ethical questions for the explorers who undertook these adventures as well as for those who supported the exploration, financially and otherwise.

In the undergraduate course in philosophy which the authors of our present paper taught, started off by asking their students well-defined philosophical questions regarding exploration. Their students were given detailed course-level objectives, objectives which were delivered by their instructors in learning modules that involve the use of virtual reality technology. The students were then asked to engage in thought-experiments, were given a list of assigned readings, and were shown a video interview with a British astronomer.

The authors share their own reflections on the educational techniques that they used in class, as well as their view of the pedagogical soundness of those techniques. They then present for our readers some students' comments on what the students themselves took to be the value of the course.

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## SUBMISSION GUIDELINES

We encourage our readers to suggest themselves as reviewers of books and other material—including technological innovations—that they think may be especially good for classroom use.

Reviewers are welcome to suggest material for review that they themselves have found useful in the classroom. However, please remember that our publication is devoted to *pedagogy in philosophy* and not to theoretical discussions of philosophical issues. This should be borne in mind not only when writing articles for our publication but also when reviewing material for our publication.

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## ARTICLE

# *The Philosophy of Space Exploration (PoSE): An Immersive Course to Explore and Inspire Next Generation Ethical Considerations*

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### 1. INTRODUCTION

The pace of innovation, exploration, and excitement about space exploration reached an inflection point some years ago and continues to gather speed. The revolution afforded by space launch companies, perhaps most readily exemplified by SpaceX, means access to Earth's orbit is now obtainable with *relative* ease and lower costs. In the USA, Space X, Blue Origin, and Virgin Galactic offer (or plan to offer) regular space flights, including private/tourism adventures. The new heavy-lift vehicles (rockets that can carry massive payloads into and beyond the Earth's orbit) hold the promise to continue to drive down greatly the costs of orbital deployment, as well as offering hitherto unheard-of capabilities to launch heavy and advanced technology into space for science, exploration, and other purposes. Recently, NASA led the development and deployment of the James Webb Space Telescope (JWST), a transformative astrophysics observatory that is already altering humanity's view of the cosmos. For example, this facility is probing the atmospheres of planets in orbit around distant stars in preparation for the search for life, as well as examining and furthering our understanding of the Big Bang, the start of the universe. Indeed, NASA is leading the early design case studies for the design of a new generation of observatories that will be able to search for life on distant planets as well as perform potentially transformational general astrophysics. The Habitable Worlds Observatory seems likely to be leveraged from these new launch facilities. Ours is a truly exciting and transformative epoch in history.

At the University of Texas at San Antonio (UTSA), many faculty are engaged in space-related research, spanning astrophysics to astronautics, from human performance in space to comparative planetary geological studies. This has been a deliberate focus of the university, which seems likely to develop further due to the aligned goals of UTSA and the state. In 2024, the state created the "Texas Space Institute," funded at a level of \$350M for the first two years of operation, with the possibility of further funds being provided by the legislature in future biennia. As stated in

press releases related to the foundation of the institute, its vision involves "expanding Texas' role as the leader in the new space economy," and leveraging "existing expertise and resources to make new discoveries, technological developments, health advances and workforce growth. It will depend on partnerships with public and private entities in a variety of sectors from across the country."<sup>1</sup> The governor challenged the universities in the state to become the first to offer the "State's first degree program in space engineering," so the drive to ensure the availability of space-related degrees is highly timely.<sup>2</sup>

It has been discussed by many, from those in industry to the United States Congress, of the lack of STEM workforce and students, and the effects this lack is likely to cause to the US economy, security, and progress. The authors strongly agree with this concern, but also note an additional lack of general awareness, that of the philosophy and ethics of space exploration. How should we think of the scientific activity involved in space exploration in comparison to other sciences? How can the problems of past "frontier" explorations be minimized (where explorers and/or natives were killed through disease or war, or were displaced, leading to complex ethical and philosophical questions), who decides who owns nonterrestrial bodies and governs their use, exploration, and even exploitation? What rights, if any, does extraterrestrial life have, and how is this decided upon? For example, if there are pockets of microbial life on Mars (or Europa, Enceladus), should those areas or bodies be quarantined? Or what if more advanced or even sentient life is found (even outside of our solar system), what rights does it have? Is the presence of sentience enough to grant rights to such life, or is some kind of test of sentience, intelligence, or wisdom required to afford a sliding scale of rights? As artificial intelligence (AI) advances, and possibly gains sentience, does this entity have legal rights? How could this question be answered, that is, what considerations could be advanced regarding a resolution? These questions will likely be faced by society, soon or in the distant future. These somewhat esoteric questions have deep roots in our own contemporary existence, and their exploration in the classroom can illustrate current and often prevalent bias and/or ethical considerations.

While the points discussed above regarding space exploration are of great interest to astronomers and many scientists and engineers, not all students have the same interest, or even support these exploration efforts. Further, as high technology advances and is deployed into the classroom in a way that changes the learning experience for students, the application of technology (such as virtual or augmented reality) to esoteric concepts could help to facilitate the understanding of the concepts. For example, it can be difficult to grasp the size of the JWST, or the probes exploring the outer solar system, challenges that can be greatly mitigated using virtual or augmented reality technologies. The experience of immersive viewing the inside of the International Space Station, or indeed the outside view, and the jarring contrast it offers between the human-made geometric structures of the Space Station and the beauty of the Earth in the blackness void of space is by far best achieved through such technologies. Further, many of the points raised in this course in the "off-Earth"

arena have a direct parallel to those on Earth, such as animal rights, property ownership, territorial disputes, etc.

The authors of this paper joined forces to (a) develop a course that fuses the disciplines of space exploration with philosophy, (b) deliver this course to a student audience who might otherwise not be exposed to such concepts and skeptical of space exploration, and (c) deliver the materials using recent technologies. To achieve (b), we did not have any course prerequisites, but we note that students who have had at least some prior courses in philosophy tended to select this course. The level of science was kept at a level appropriate to ensure those who did not major in a scientific discipline would be able to fully contribute and pass the course.

We highlight that our course offered an applied framework in which to think about the seminal issues in philosophy of science by using “space exploration” as an exemplar of scientific activity. These philosophical problems include the demarcation problem, the nature of scientific explanation, and scientific method. Insofar as the course examined such questions in the context of space exploration, a form of scientific activity that has bearings on various questions about humanity and morality, we have also engaged with various ethical questions. In addition, our course employed a tool that is often used by philosophers, i.e., we

employed thought experiments to help students explore questions and test intuitions about topics pertaining to space exploration. We set course-level objectives and then flowed these through a total of ten separate modules, each with their own module objectives as shown below:

**COURSE-LEVEL OBJECTIVES**

Evaluate the difference and relationship(s) between science and pseudo-science.

1. Apply scientific knowledge in a philosophical framework to reach reasoned conclusions on “future” space-related issues.
2. Evaluate current issues that could help/hinder space-related progress and explain reasoned solutions.
3. Compare scientific and ethical reasoning/thinking of space-related issues.
4. Apply digital literacy tools to illustrate and articulate space-related issues.

In what follows, we discuss the class materials, goals, and evolving scenarios used for coursework, our use of new technologies, the reactions and self-reflections concerning

**MODULE OBJECTIVES**

Module	Topics & Module Objectives
What Is Science?	Evaluate the difference between science and pseudo-science Illustrate the characteristics of scientific reasoning, i.e., how it is different from or similar to other forms of reasoning, such as moral reasoning, religious reasoning, etc.?
History & Future of Astronomy	Describe the historical relationship between astronomy and philosophy Compare and contrast the historical information with contemporary approaches
History & Future of Space Exploration	Identify the benefits and risks of space exploration Distinguish the characteristics of successful space explorations from unsuccessful ones Critique the USA space program and highlight to areas of strengths and weakness
Is Exploration Truly “Science”?	Compare and contrast arguments for and against thinking about space exploration as scientific
Space Ethics	Evaluate the benefits and harms of space exploration from an ethical perspective Examine the tensions and conflicts between scientific (practical?) and ethical outcomes
What Is Life? Biological & Digital	Compare and contrast the various definitions of biological life Analyze definitions of “life” and “sentience” to identify similarities and differences in how “life” and “artificial consciousness” might be understood Briefly describe how the search for life can be pursued using observations (in situ and remote)
Who “Owns” the Moon? Mars? Beyond?	Critique the optimal areas (?) and reasons for Moon/Mars exploration, settlement, and usage Apply knowledge of Earth’s exploration and settlement to potential problems of Moon/Mars
Does ET Life Deserve Human Rights?	Critique and analyze human rights, and animal rights to observe the differences and/or similarities between the two? Extrapolate in a reasoned manner how we could define rights for possible ET life.
The Search for ET Intelligence	Critique and analyze the SETI approach Discuss the answers to the interview questions of the SETI staff member
What Happens When We Find Life in the Universe?	Consider and apply historical precedent to estimate the likely implications of finding life in the universe Consider and apply historical precedent to estimate the ethics of finding life in the universe

them from the students, the author's reflections, suggestions for future improvements, and, finally, summarize our results.

## 2. SUMMARY OF COURSE CONTENT AND DELIVERY

In this section, we briefly summarize how the materials of each class build a coherent understanding of space exploration and ethics. We also summarize how virtual reality technology was used for delivery of the content. We highlight that what made this course thoroughly interdisciplinary was requiring students to read and conduct research based on both philosophical texts and scientific texts and materials. Having a philosopher and scientist collaborate to teach this course enabled us to both present scientific theories with regards to space exploration and address various philosophy of science and space-ethics-related questions that emerge from them. Instructors were present in each class and were able to respond to students' questions and guide them as they learned the science and engaged with the philosophical and ethical questions.

### 2.1. COURSE CONTENT

#### Module 1: What Is Science?

In this section, we evaluated the historical and philosophical significance of separating science from pseudoscience by focusing on what philosophers call the demarcation problem. We first focused on Popper's concept of falsification, according to which a theory is scientific if it is falsifiable, i.e., if it can be tested and potentially refuted by evidence. Next, we turned to Thomas Kuhn's view that science is characterized by the presence of paradigms that guide research; shifts between paradigms (scientific revolutions) are based on sociological and pragmatic factors, complicating demarcation. Students were assigned two chapters from an introductory textbook in philosophy of science,<sup>3</sup> and an overview of recent philosophical work on space exploration.<sup>4</sup>

#### Module 2: History & Future of Astronomy

In this module, the progress of astronomy from its use for creating calendars and guiding navigation to the James Webb Space Telescope (JWST) that revolutionized astrophysics was discussed. We spent considerable time on the change from the geocentric to heliocentric views of the universe, from the Galilean telescope that challenged traditional Catholic teachings in astronomy, to the understanding today that exoplanets are numerous in our galaxy, and current plans to search for biomarkers in those planets. As the JWST was just launched, we also discussed some of the latest images produced by this incredible new observatory, placed in historical context. Students were assigned readings on historical and philosophical dimensions of the Galilean and Copernican revolutions,<sup>5</sup> and an overview of NASA's website dedicated to JWST.<sup>6</sup>

#### Module 3: History & Future of Space Exploration

We started this module with a recap of dreams and fears of space travel, for example, by Jules Verne (*From the Earth to the Moon*) and H. G. Wells (*War of the Worlds*), the grounding of rocket science in World War II (especially the Nazi scientists/engineers), Soviet domination of the start of the "Space Race," and the eventual "Moon Race," culminating in Armstrong's first steps on the Moon, which demonstrated the incredible triumph of American engineering astronautics. We next discussed the Space Shuttle era, both the high and low points, and finished with the incredibly rapid progress in recent years of programs such as SpaceX's Starship, Blue Origin's New Glenn, and NASA's Space Launch System. We examined the promise of these new breeds of spacecraft and hinted at discussions that these incredible new rockets will inspire. Further, the implications to society were explored as the landscape rapidly altered, and the motivating concepts (both publicly and privately) were examined. Background readings included an overview of the legacies of the Space Shuttle<sup>7</sup> and an examination of the relationship between technological advances and social progress.<sup>8</sup>

#### Module 4: Is Exploration Truly "Science"?

This module focused on examining whether space exploration is an authentic scientific enterprise. To illuminate the discussion, we examined the similarities and differences between the polar expeditions of the nineteenth century and contemporary space exploration. The discussion highlighted the commonalities such as embodying the human spirit of curiosity and resilience and the pushing of the limits of human endurance in confronting the unknown; and differences such as space missions emphasizing international cooperation, unlike the nationalistic focus of many polar expeditions. Readings included an article on whether exploration is science,<sup>9</sup> and the Library of Congress's overview of polar expeditions of the nineteenth century.<sup>10</sup>

#### Module 5: Space Ethics

This module explored the ethical considerations in space exploration, including environmental, societal, and legal issues, to evaluate critically humanity's responsibilities on and beyond Earth. From the lens of environmental ethics, we examined practical questions surrounding the preservation of extraterrestrial environments (e.g., avoiding biological contamination of Mars with terrestrial biological matter), as well as mining asteroids and leveraging space resources (for example, which nation/consortium/company can claim "ownership" of asteroids/meteoroids and their potentially rich resources, and where/how should they be "disposed" of after use?). We also evaluated the societal impact of space exploration such as equity—who gets to participate and benefit—and addressed the potential militarization of space. Assigned readings included an article on environmental ethics related to making Mars habitable,<sup>11</sup> and a paper on making space exploration accessible.<sup>12</sup>

**Module 6: What Is Life? Biological & Digital**

For many students, even of astrophysics and/or exoplanets, it is startling to realize that there is no generally accepted definition of life. We discussed some of the pros and cons of competing definitions by engaging with the philosophical literature. We noted that we have only one sample of life in the Universe: life on Earth. We remain fundamentally trapped in this narrow view until we can find extraterrestrial life, perhaps in the Solar System or beyond. The current estimates for how prevalent life might be was examined using the Drake Equation (an equation used to estimate the current number of intelligent civilizations in the universe), and, more interestingly, how common extraterrestrial intelligent life might be now. Finally, we discussed the Fermi Paradox (If life is prevalent in the universe, as seems likely to many, why has the Earth (apparently) not yet been visited by such life?), and the author’s views on UFOs and the (almost) certainty that they do not represent extraterrestrial visitors. Assigned readings covered material on the definitions of life and artificial life in the context of scientific explanation,<sup>13</sup> and the social and ethical implications of creating artificial cells.<sup>14</sup>

**Module 7: Who “Owns” The Moon? Mars? Beyond?**

Legal ownership of the Moon was first claimed by an individual in 1980, reminding us inadvertently that laws pertaining to space exploration and “ownership” are lacking. We examined the 1967 Outer Space Treaty, and the changes the 2020 Artemis Accords hold. The lack of international consensus on this rapidly evolving legal area is a cause for concern. We covered material including the colonization of space and existential risk,<sup>15</sup> and scientific and ethical implications of making Mars habitable.<sup>16</sup> Students also watched Isaac Arthur’s documentary on industrializing the Moon.<sup>17</sup>

**Module 8: Does ET Life Deserve Human Rights?**

Whether extraterrestrial (ET) sentient life that has intelligence that is similar to or exceeding humans deserves human rights brought issues in social and political philosophy about human rights to bear on the rights of possible ET life in space. Through a reading of philosophical text on human rights, students explored whether they are applicable to ET life. Focusing mostly on how humanity should approach the discovery of intelligent life, we discussed possible frameworks for guiding ethical communication, fostering mutual respect, and avoiding harm. We wanted to ensure that both sentience and intelligence levels were expressed as similar or exceeding humans to avoid the discussion of if such life were inferior to human life, human rights should not be extended to it. Assigned readings included Peter Vickers’s assessment of finding alien life and Peter Singer’s work on alien rights.<sup>18</sup>

**Module 9: The Search for ET Intelligence**

We had the opportunity to invite Dr. Franck Marchis from the Search for Extraterrestrial Institute (SETI) as a guest into our class. He and the students have engaged on various topics, including the following:

- What is SETI, what are its goals, and who funds it?
- Do you think there is life outside the Earth?
- How probable is intelligent life?
- Why haven’t putative ET intelligences contacted us yet?
- How will society deal with the discovery of ET life? What are the cultural, theological, and philosophical implications of such a discovery?
- Does intelligent ET warrant human-like rights and protections?
- Does AI deserve rights if it becomes very smart, self-aware, or sentient?
- Who speaks for Earth?

**Module 10: What happens when we find life in the Universe?**

In the final module we hosted a video discussion with a leading UK astronomer, Dr. Martin Ward, Temple Chevallier Chair of Astronomy. He has given testimony to the UK’s House of Lords about what happens when we find intelligent life in the universe. In this wide-ranging discussion we explored some peer-reviewed literature on the subject, as well as the societal implications this momentous discovery would have on the general population.

**2.2 CONTENT DELIVERY VIA VIRTUAL REALITY TECHNOLOGY**

For this course, we purchased and distributed virtual reality (VR) headsets to all the students and instructors. Our objectives in using VR were twofold: (1) Provide an immersive experience for several of the assignments and (2) Enable virtual “round-table” discussions using student-designed avatars in the Horizons workspace area, a software platform provided by Meta.

To achieve the goal of immersive experience, there are now abundant materials available. These enable a 360-degree experience in exploration of the International Space Station (ISS), extravehicular activities beyond the ISS, astronaut training, preparation for Moon/Mars exploration, rocket launches, and more. The experience of being able to see, for example, the stark contrast between the blackness of space, the angular, grey, and human-constructed ISS, and the beauty of the Earth’s disc through VR was cited by several of the students as an experience that was profoundly different from seeing the same materials on a TV screen or photo. Experiencing low Earth orbit, astronaut training, and the type of exploration that Mars surveys afford through VR achieved the goal of inspiring the students who might not otherwise have been so interested. Several graded assignments were made which used available immersive videos, with follow-up multiple choice questions asked to ensure the students watched and absorbed the key messages from those videos.

We also hosted VR weekly discussions of the materials covered in that week’s class (Figure 1). We chose to do this online (synchronously) to offer location flexibility to the students, and, in the VR environment, to understand the pros and cons of doing so. Students were free to make their own avatars and would be randomly positioned around a large virtual round table where discussions could be made, as well as virtual presentations from “real” computers projected to the virtual world. In the early classes it was notable that some students were more vocal than others, but as the novelty of the VR environment passed, even students who self-identified as shy spoke often and with conviction. Indeed, some of those we spoke to suggested that having an avatar presence rather than their real physical presence made voicing their opinions easier.



Figure 1. Discussion in the VR environment, showing the student avatars, the presentation from a real computer and a projector to the main screen, seen from the point of view of the authors. The avatar “look,” clothing, etc. were selected by the user and could be updated, but we note that the students and faculty chose avatars that physically looked and dressed like the person in real life. Their arms and hands moved in synchronicity with the person in real life.

### 3. PHILOSOPHICAL QUESTIONS INDUCED BY AN UNFOLDING THOUGHT EXPERIMENT

Through the duration of the one-semester course, an unfolding thought experiment was created, augmented by four mission updates, each with a philosophical question. Each member of the class was integrated into a group which then submitted to the instructors a document or video (for the last assignment only) explaining their answer to the question and their reasoning. We chose to set out a somewhat gloomy but possible near-future dystopian view of a future Earth. In this scenario, weather changes have created extreme events and changed rainfall patterns, leading to global instabilities associated with food and water supplies. Upgrades to human brainpower were available to the super-rich, leading to governance issues.

Space junk and advertising from space has made low Earth orbit almost unusable and dangerous to traverse to higher orbits. Human Mars landings have begun and hold the promise to help address problems on Earth or even use Mars as a “second Earth.” The human Mars exploration is aided by sentient (AI) cyborgs, but the ethics of their use has not been resolved.

In our first update (Figure 2), NASA launched two humans and two sentient AI cyborgs to Mars to search for life, but a malfunction due to space debris caused insufficient power to be generated by the solar panels, meaning either the power-hungry AI cyborgs had to be powered down (leading to their permanent demise) or the oxygen scrubbers, essential for the human life support system, had to be stopped. The questions were as follows: Which path should be followed? Why this path? What effects will it have to the mission objectives? Finally, what ethical guidelines might be involved in this choice?



Figure 2. Video banner for our first mission update.

In the second and third updates, we said that life was found in the arid areas of Mars, which initial tests showed could help with understanding how to grow crops on Earth, especially those in the areas that recently experienced desertification. Two alternatives were presented: to study the life in relatively basic space-based laboratories, which would likely take years, or to bring the samples of Martian life to Earth-based facilities, accepting the risks of possible contamination but yielding results far more quickly. As crops on Earth are failing, the potential advances in yields could save many lives, but the risk of contamination to the Earth remains. We asked what should be done with these samples, and what practical considerations would have to be made? A further question was presented about the appropriateness of disturbing the Martian life, and if it should be left on Mars in a protected manner. Issues of rights, land ownership, and their ethics were raised and discussed.

Finally, in our fourth update, the upgraded humans formed their own governance structure and planned to beat NASA to the area where life had been found, secure the area, and remove the life back to the Earth’s surface for maximal commercial exploitation. What are the pros and cons, and what are the ethics of this approach? If NASA were to try to stop this approach, how would it do so, and with what ethical considerations?

#### 4. EVALUATION OF STUDENT COMMENTS ABOUT THE COURSE

We anticipated there would be two fundamental challenges to teaching the Philosophy of Space Exploration course. The first concerns the difficulty of philosophy classes in general. The subject matter requires high-level critical thinking, analysis of abstract concepts, and strong reading and writing skills. These can be challenging for many learners, especially when compared to more concrete subjects with clear-cut answers.

The second challenge we anticipated had to do with the complexity of space exploration. Understanding space science demands a strong foundation in mathematics and physics, and the ability to interpret complex data related to phenomena not directly observable in daily life. This is particularly difficult for students whose backgrounds are primarily in the humanities; the enrolled students might not have encountered many space-related materials. We were therefore concerned that some might have a difficult time completing the required readings and the writing assignments. Similarly, we anticipated that students might be intimidated to speak up in class and engage in critical thinking and reflective engagement about the material, and thus we ensured good contact to all students (offering office hours, email, Zoom, VR, or Slack help) and ample introductory materials to ensure an equal chance of success.

To address these potential challenges, we employed three innovative pedagogical and technological approaches. First, we used accessible educational materials. Instead of relying only on complex readings, the course supported this material with short, easy-to-understand handouts for the assigned readings and pre-recorded video lectures. Second, we used VR technology to aid learning. Specifically, students used VR goggles to access space-related materials created by NASA and partners, which fostered engagement and immersion in the subject matter. Finally, we offered an interactive classroom environment with the use of VR for interactive class discussions and collaborative learning.

In what follows we will evaluate the feedback we received from students about the class. This feedback illustrates that our pedagogical innovations were helpful in overcoming the challenges and resulted in a mostly positive class in which most students succeeded.

Our observation is that most students were initially skeptical about the course. In the first couple of weeks of the class, as the early material unfolded and the Mission Updated assignments were given, students said that they did not appreciate the importance of thinking about space exploration through the lens of philosophy of science. Some students expressed worries about how much funding was being dedicated to research in space exploration and suggested that those funds could better be utilized in the context of healthcare, for example, by way of increasing funding for cancer research or making healthcare more affordable. Similarly, students did not think that philosophy was relevant to space exploration; some have pointed out that philosophy focuses on abstract ideas and logic

whereas space science is all about experimentation and technological innovations.

However, students' views evolved as the course progressed. We tracked their assessments of the course content weekly. The feedback indicates that the combination of accessible materials, VR technology, and the interactive classroom created an engaging learning experience and overcame students' initial doubts and fostered successful learning outcomes.

We found three main themes in the student feedback. These are the appreciation of the (i) value of philosophy in space exploration, (ii) benefits of VR technology to deliver the course content, and (iii) quality of engagement via the Horizon platform in VR in comparison to other learning environments (such as Zoom). We discuss these in turn.

##### THEME 1: THE VALUE OF PHILOSOPHY IN SPACE EXPLORATION

Students recognized that philosophy is important for space exploration for a variety of reasons. First, they pointed out that philosophy teaches how to think critically and ask questions and thus it is useful in space science. For example, one student wrote, "Philosophy plays a critical and fundamental role in the development of human values." Similarly, another student wrote, "Philosophy would help prevent or avoid catastrophic scenarios by strengthening problem-solving skills through a more rational, critical, and reflective process."

Second, students noted that philosophy promotes ethical reasoning and decision-making and argued that philosophy can help assess the ethical dimensions of space science. One student wrote that "Philosophy can help prevent or avoid catastrophic scenarios by helping those in charge take the right decisions." Another student wrote, "Philosophers could try to maximize the good in the situation by analyzing the situation and determining how practicality and ethical solutions could be achieved." Yet another student wrote, "Philosophy involves at least the conversation of morality, which in desperate times can often be erased from scientific discovery."

These themes collectively highlight that students have recognized the complexity of integrating philosophical inquiry into the rapidly advancing fields of science and technology and appreciated the need for critical thinking and for raising ethical considerations in the face of potential future challenges generated by space exploration.

##### THEME 2: BENEFITS OF VR TECHNOLOGY TO DELIVER COURSE CONTENT

Students expressed in their comments their appreciation of the delivery of the course content through VR technology. They highlighted three main reasons. First, many students suggested that because VR created a realistic and immersive experience, they were able to stay focused and engaged in the content. One student wrote, "I typically struggle staying focused in class but the ability to be completely in it really helped me." Another student wrote, "I found

it really interesting whereas if I were to watch this video on my laptop, I would have not paid that much attention." Similarly, another student wrote, "If I watch just a regular YouTube video or read the same information in a book, I won't grasp information because I can get distracted very easily."

Commenting on the realistic aspect of the experience, another student wrote, "Seeing these workers in special suits and hearing the roar of the ventilation allowed me to feel immersed in their environment." Yet another student wrote, "I even felt a little cold being in the environment."

Second, many students commented that VR technology helped them understand the content better and increased their interest in space. One student wrote, "I found the VR experience to be very interesting, and I feel like it helped me understand what it looks like to be inside NASA training facilities much better than videos." Another said, "I feel that using virtual reality has caused me to engage with this class more which has ultimately impacted my learning experience positively." Another student wrote, "I definitely think that since I've started using the VR headset . . . my interest in space has increased." Yet another stated, "being able to see certain things in 3D that I will probably never have the opportunity to actually see in real life, is really amazing." Another student said, "Seeing the large size of the telescope . . . I was shocked at how large it was and that it had 18 mirrors."

Third, students expressed how they became emotionally connected to the course content and how this enhanced their appreciation of the material. A student wrote, "The fact that I can place myself in the steps of these brave astronauts . . . makes me feel so emotional." Another student wrote, "Seeing the JWST through the VR made me feel a bit emotional . . . of how much work and years of research I imagine was put into building the technology." Yet another student stated, "I felt so small and insignificant, in comparison . . . overwhelmed, astonished, and taken aback." Finally, another student wrote, "I feel that this new way of taking in information allows me to feel more connected to the material."

Overall, students highlighted in their comments the transformative nature of VR technology as an educational tool, emphasizing its ability to create immersive, engaging, and emotionally resonant experiences that enhance understanding and focus compared to traditional media. This made space exploration more accessible, interesting, and engaging for students.

**THEME 3: THE QUALITY OF ENGAGEMENT VIA VR MEETING ROOM VS. OTHER LEARNING ENVIRONMENTS**

Students gave three reasons for their appreciation of the VR meeting room over other online learning tools. First, they noted that the VR meeting room gives a more in-person feel and thus aids engagement. One student wrote, "I prefer to use the VR meeting room because it gives the class a more in-person feel rather than Zoom where everybody usually has their cameras off." Another said, "The experience is

much more intimate & less intimidating than a traditional classroom."

Second, they wrote that they liked being able to personalize and better represent themselves in VR through the avatars. One student noted, "I like the concept that everyone has an avatar that represents how they feel inside, and I feel like it makes people more confident when they're talking." Another one wrote, "I have personalized my own workroom with posters."

Finally, students said that the VR meeting room allowed them to collaborate and interact better with their teammates. One student wrote, "My favorite feature using workrooms is the board where my groupmates and I can collaborate and write down all our ideas."

These themes demonstrate the strengths of VR in education, particularly in fostering engagement, enhancing understanding, and providing unique, immersive experiences, while also addressing the comfort levels of students in virtual environments.

**5. LESSONS LEARNED & FUTURE WORK**

Unifying space themes with philosophy in a high-technology delivery system enabled us to reach a student body that would otherwise have been unlikely to engage with these materials. The medium of outer space remains remote to most of us, but the questions and discussion points echo clearly some terrestrial and contemporary issues. For example, the discussion of whether intelligent extraterrestrial beings have rights drew directly on questions of human rights and why they are important to humans; the discussion of AI was similar, and indeed we set up a modern-day "trolley problem" where a self-driving car was on a collision course with a group of humans and could only be diverted if someone swerves the car to let it collide with a smaller group. The ethical questions related to who owns the Moon and Mars relate to eminent domain and/or the historical exploration of "new" lands and/or colonization. Framing the questions as if in outer space allowed for more "free" thinking, but we were often brought back to Earth, for that is where our ethics are framed. Students quickly absorbed the materials and engaged in the discussions, and as the course progressed, they grew to recognize the importance of space exploration, but also the challenges it entails. The questions and discussions raised will need to be debated more broadly by society at large and will continue to be informed by current (i.e., existing) thinking, likely evolving slowly and constrained by existing social thinking and its assumptions. By asking and addressing difficult and fascinating ethical questions related to space, we hope and believe that a student group that would otherwise have not been interested in such initiatives left inspired and enthusiastic to continue their explorations in the humanities.

The use of VR technology achieved the immersive experience we were hoping for, and this was remarked upon by many of the students. Both in the VR assignments and the virtual discussions, the technology was stable and mature. The discussions were flowing, and were much like those around a physical table, but were potentially

improved due to the avatar speaking, not the real human, again as reported by several students. We attribute a significant part of the increased enthusiasm for space exploration by the newness and immersive nature of VR and the availability of high-quality materials from NASA and their partners and associates.

We hope to teach this course again, following an approach similar to our first run. VR technology continues to improve and hence the experience and associated boost in space exploration appreciation could increase accordingly. We would like to update our materials, and we welcome discussion from readers and the community as to their suggested improvements. To conclude, we stress again that the pace of change in space exploration, AI, and associated areas is increasing rapidly, which will naturally lead to associated ethical considerations. Thus, we are convinced that this course is new, novel, timely, and needed.

#### NOTES

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13. Lange, "Life, 'Artificial Life,' and Scientific Explanation"; Cleland, "Life without Definitions."
14. Bedau and Triant, "Social and Ethical Implications."
15. Gottlieb, "Space Colonization and Existential Risk."
16. McKay and Marinova, "Physics"; McMahan, "Aesthetic Objection."
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