SPENCER FOUNDATION

Large Grant Request ID# 10056505

Spencer Foundation Proposal Details:

Administering Organization: University of Georgia Research Foundation, Inc.

Legal Name: University of Georgia Research Foundation, Inc.

Principal Investigator: Professor Inseok Song

Project Title: Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning

Request Amount: $247,325.00

Request ID: 10056505

Signature from Authorized Representative of the Administering Organization

The proposal referenced above is approved for submission to the Spencer Foundation. The proposal details can be found on the pages following this signature page.

{{_es_:sender:Spencer Foundation}}
{{_es_:signer1:signatureblock}}

Name: Alex Newell

Title: Research Funding Administrator

SPENCER FOUNDATION

Large Grant Request ID# 10056505

Administering Organization

Organization: University of Georgia Research Foundation, Inc.

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Title: Associate Professor

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Confirmation: I confirm that neither the PI nor the Co-PIs have another research proposal under review at Spencer.

Proposal Summary

Proposal Title: Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning

Project Start Date: 01/01/2025

Project End Date: 12/31/2027

Number of months for project: 36

SPENCER FOUNDATION

Large Grant Request ID# 10056505

Requested Amount: $247,325.00

Central Research Question(s): Please state the central research question(s) this project seeks to explore or answer.

Enhancing Astronomy Undergraduate Education with Immersive Technologies

Project Summary (200 word limit)

The proposed project comprises two interlinked initiatives designed to improve the quality of instruction in astronomy and broader STEM education, while also evaluating their impacts. The first initiative addresses the shortcomings of existing astronomy resources, which often struggle to effectively illustrate complex 3D phenomena due to their reliance on 2D media such as paper, whiteboards, or computer images. To address these shortcomings, we plan to create a series of 3D astronomical simulations that can be viewed on 2D displays, VR headsets, or as AR versions on smartphones or tablets. We will evaluate the effectiveness of these simulations by collecting classroom data, measuring user engagement, and comparing these simulations with other instructional methods.

The second initiative involves developing a curriculum for introductory astronomy courses that incorporates the use of low-cost telescopes (<$100). These telescopes can be used individually or in small groups, allowing students to conduct observations from home and thereby enhancing their active learning experience. Ultimately, we aim to use these resources to boost scientific literacy among the general public, with a particular focus on underprivileged communities. Our initiatives will significantly contribute to the advancement of astronomy education and engagement, fostering a deeper understanding and appreciation of the subject.

Proposal Narrative Word Count: Please provide your total word count. This narrative may not exceed 5000 words. Your reference list will not count toward the 5000 word limit, nor will any text contained in any tables and figures.

4,875

Authorized Signatory Information

Signatory Name: Alex Newell

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Attached Documents

Proposal Narrative: ProjectNarrative.pdf

Proposal Budget: Budget Form

Project Timeline: Timeline.pdf

Project Team: ProjectTeam.pdf

Appendices A:

Appendices B: Letter_of_Collaboration_Nandana_Weliweriya.pdf|

Appendices C:

PI CV: CV.pdf

Co PI CV's:

Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning

1 SIGNIFICANCE OF OUR PROPOSED STUDY

Reports from around the world and within our nation indicate a growing need for our students to be better informed about STEM (Science, Technology, Engineering, and Mathematics) degrees and the associated career opportunities. These fields hold the promise of a bright future. There is a pressing need to bolster STEM education, with a special emphasis on astronomy, by incorporating contemporary resources like immersive technologies. Such an approach will not only draw more students towards STEM but also sustain their interest and curiosity over time.

1.1 IMPORTANCE OF STEM EDUCATION

Enhancing STEM education across the nation is a top priority, as underscored in the strategic goals, mission statements, and reports from the Department of Education, NSF, and NASA: "*To maintain the nation's leadership in science and technology discovery, we must create an approach to STEM education that prepares and advances the U.S. for the future … we must consider the entire education ecosystem so that children of all backgrounds, race, ethnicity, gender, religion and income levels can learn the wonders and possibilities of STEM and maintain that interest and passion throughout their lives.*" STEM educators must prepare students with necessary skills and experiences to become tomorrow's creators and STEM workforce. Our project, as outlined in this proposal, offers training, support, community, and resources to students majoring in STEM, providing them with invaluable experience with modern immersive technologies. Our proposed work represents a shift in thinking about STEM education, aligning with the national priorities mentioned earlier.

In comparison to major countries like China, Russia, and Germany, where approximately 40% of graduates major in STEM fields, the United States stands at 20% as of 2020 [1]. It's crucial to attract more students to the STEM field and sustain their motivation to uphold our leadership in STEM talent in a progressively competitive global landscape. STEM educators must discover effective methods to continuously engage and challenge students already pursuing STEM majors.

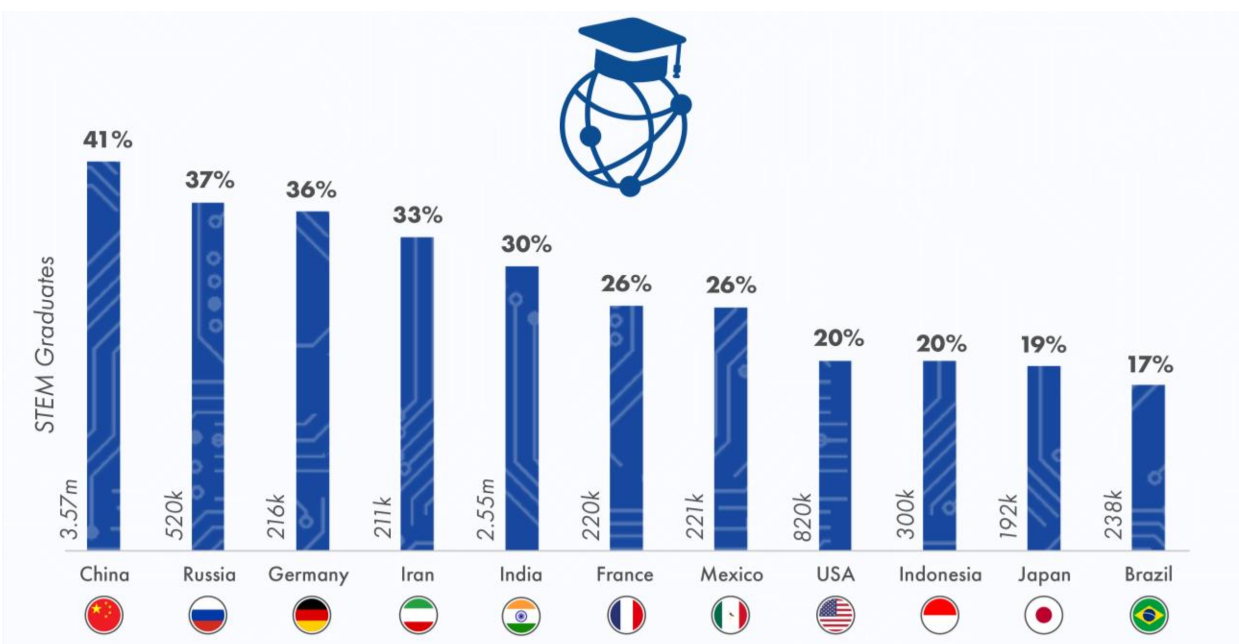

Figure 1: Percentage of total graduates in STEM fields among top leading countries [1]

Despite acknowledging the importance of STEM education and our concerted efforts, we've seen limited success in motivating students to pursue STEM careers [2]. This is largely due to the traditional teacher-centered approach, which assumes knowledge can be directly transferred from the instructor to the students. Over the years, technology has revolutionized our world and daily lives. Along with that, technology has also begun to change the roles of teachers and learners in all settings. Technology plays a crucial role in facilitating collaborative learning while it helps students research subjects, share ideas and learn specific skills. Besides, during the mid-part of the spring 2021 semester, the COVID-19 pandemic forced the conversion of well-designed in-person instruction methods to online teaching methods. Modern learning theories, such as situated cognition, suggest that knowledge is constructed within a student's socio-historical context through active sense-making processes [2, 3, 4]. Therefore, it is essential to transition to a student-centered learning environment that fosters active learning opportunities.

1.2 IMPORTANCE OF ASTRONOMY EDUCATION

Astronomy, a key subject in the STEM field, plays a vital role in STEM education [5]. The study of the universe and celestial bodies often ignites curiosity and inspires students to learn more about nature, potentially leading to a lifelong passion for learning and scientific discovery. It offers an interdisciplinary learning platform, integrating aspects of mathematics, physics, chemistry, computer science, and other STEM disciplines. This interconnectedness helps students understand how different STEM fields complement each other. Astronomy, a testbed for new technologies and discoveries like radio communications, detectors, and telescopes, allows students to gain a hands-on experience of these technologies and their research applications. Furthermore, astronomy provides a global perspective, emphasizing our shared place in the universe and promoting unity and shared responsibility for our planet. With the growing interest in space exploration and potential human colonization of other planets, astronomy knowledge will become increasingly important. Students with an astronomy background will be well-prepared for careers in this exciting field.

Despite the benefits of astronomy education, including its interdisciplinary nature, inspirational value, and global perspectives, we live in a world grappling with immediate problems like hunger, poverty, energy, and climate change. Pursuing fundamental questions in astronomy may require practical justifications compared to other STEM fields like engineering, which have more immediate real-world applications. However, as Dr. Ahmed Zewali, the 1999 Nobel Laureate in Chemistry, stated, "*Preserving knowledge is easy, and transferring knowledge is also easy. But making new knowledge is neither easy nor profitable in the short term. Yet, fundamental research proves profitable in the long run, and, as importantly, it is a force that enriches the culture of any society with reason and basic truth*." As one of humanity's most fundamental research fields, astronomy is at the forefront of STEM, answering fundamental questions and driving innovation.

Therefore, it is essential to inspire curiosity, create opportunities for hands-on experiments/trials, and prepare future generations for a world of exploration and discovery [5]. Moreover, learning about space and astronomy is an excellent way for students to enhance their understanding of math and physics and improve their 3-D problem-solving abilities [6]. Enhancing STEM and astronomy education with modern approaches is imperative.

2 FRAMEWORK

Traditional astronomy education frequently uses 2-D illustrations to represent complex 3-D real-world scenarios, leading to misunderstandings and obstacles that impede a thorough understanding. The gap between textbook concepts, problem representations, and real-world applications can result in increasing student frustration and a declining interest in pursuing STEM fields.

2.1 DIGITAL TRANSFORMATION IN EDUCATION

Recent innovative pedagogical approaches in Physics and Engineering have adopted modern technology in instruction [7-15]. For instance, Wieman et al. and Christian et al. have spearheaded the development of virtual physics using interactive computer simulations[1] (PhET and Physlet simulations) to illustrate fundamental physics concepts [16-18]. While these simulations can help students visualize physical concepts, they do not promote active learning in real-world contexts, and these PhET/Physlet simulations are still 2-D.

Immersive technologies, including virtual reality (VR), augmented reality (AR), and extended reality (XR), are driving digital transformation in education and offer numerous advantages over traditional educational materials [19]. They can enhance engagement, improve understanding, increase accessibility, develop cutting-edge skills, facilitate cost-effective learning, enhance collaboration, provide real-world applications, prepare

[1] http://phet.colorado.edu and http://webphysics.davidson.edu/Applets/Applets.html

students for STEM careers, foster creativity and innovation, and creates opportunities for research on assessments [20-22].

Recognizing the importance of enhancing astronomy education amid ongoing digital transformation, we aim to develop a set of **scientifically accurate, immersive, engaging, visually stunning, and modular 3-D astronomical models** as open educational resources within the scope of this proposal. These 3-D models, designed to enhance students' understanding of fundamental astrophysical concepts, cover about 30 topics where 3-D simulations can significantly enhance comprehension and generate interest.

Our 3-D models will be adaptable and accessible, catering to various educational settings. They are purpose-built to teach specific astronomical concepts and can be deployed in multiple formats, including traditional VR, AR, and 2-D dynamic web simulation. Simulation-related tasks can be assigned as pre-class work preparing for each class or in-class activities. For instance, an activity/worksheet developed around a 3-D model embedded into a QR code can be displayed in the classroom that lead individuals or groups of students to engage with the 3-D model, leading to a deeper understanding of complex concepts. We are also working to integrate AR capabilities, making these simulations accessible via smartphones or tablets. Our ultimate goal is to develop interactive immersive 3-D models that can serve as practical labs, ensuring a comprehensive, hands-on learning experience. Thanks to the diversified deployment possibilities of these models, the limitations of devices owned by students can be overcome.

High-quality 3-D models with interactive and intuitive user controls can captivate students, allowing them to gain invaluable insights into related astronomical phenomena. These immersive simulations can enhance students' understanding of the content by improving their ability to visualize challenging content [23]. This approach allows for active and flexible engagement in astronomy education, and engaging more senses in the learning process can enhance the understanding and retention of difficult topics [24].

As we progress with this project, assessing the effectiveness of our models is crucial. This assessment will include testing students' understanding of concepts, measuring user engagement, collecting user feedback, comparing the efficacy of our models with other instructional resources, evaluating technical performance, and comparing different instruction modes.

3 METHODS

With the support from several small internal and external grants, we've already obtained approximately 20 sets of VR headsets. These will be utilized for the creation of 3-D models and pilot tests in the classroom.

3.1 DEVELOPING N~30 ASTRONOMICAL 3-D MODELS

Current astronomy education resources, particularly illustrations and figures, are generally 2-D, limiting students' ability to grasp the underlying concepts of fundamentally 3-D phenomena. One of the main reasons students are drawn to astronomy is the awe-inspiring beauty of celestial objects. However, 2-D static figures often fail to meet students' and instructors' expectations, leading to a lack of motivation to continue in astronomy and broadly in STEM. These 2-D figures, inadequate for accurately depicting complex 3-D real-world scenarios, often hinder students' comprehensive understanding and even contribute to misconceptions. The situation for 3-D illustrations is worse, with only a few freely available, often rudimentary with solid geometrical objects. Limited opportunities to engage with and solve real-world problems can diminish students' interest in the STEM fields. Our project aims to address these challenges by providing essential connections to real-life scenarios and enhancing the representation of 3-D concepts often overlooked in traditional astronomy education resources.

Several faculty members in the Department of Physics and Astronomy at PI's institution have been actively working to enhance STEM undergraduate education by adopting the potential of immersive technologies, including VR. Currently, nine faculty members from the University System of Georgia, including one from Georgia State University, are actively engaged in our education project, STEMin3D, with the aim of developing immersive education resources by adopting 3-D immersive technologies. Investigators of the current proposal are active leaders of the STEMin3D project.

Two educational theories, cognitive load theory and social semiotics, can be applied to design and measure the impact of utilizing 3-D models in astronomy education, in addition to standard performance-based metrics. Cognitive load refers to the demands on a student's memory to process information and solve problems. Semiotic resources refer to the means a student employs to convey meaning and can be displayed in many forms [25]. Schnotz and Kürschner [26] explain three main types of cognitive load: intrinsic, extraneous, and germane loads. Intrinsic load comes from the natural complexity of a learning task. Within astronomy, many topics have high intrinsic loads due to their 3-D nature and interactions. The extraneous load comes from the format of instruction or task. The difficulty in mapping inherently 3-D concepts down to two dimensions and creating scientifically accurate diagrams leads to increased extraneous load. The germane load refers to the mental task of integrating new information into previous knowledge. This task is often difficult in astronomy as students often hold misconceptions about astronomical phenomena [27-28]. As demonstrated in the pioneering study with VR for the topic of lunar phase, Blanco et al. [29] emphasized the importance of carefully selected topics to maximize the pedagogical potential of immersive technologies. Otherwise, new approaches can be deemed to be less efficient similar to those of traditional approaches.

Out of the topics discussed in undergraduate level astronomy courses, we have already identified about 30 relevant topics (Table 1 and Table 2) where 3-D models can significantly enhance students' comprehension of core concepts and ignite a heightened interest in those core concepts. Our selections represent topics with high intrinsic and extraneous loads, but, with the 3-D models, lowering the germane loads to absorb new concepts. During the first year of the project, we will create models for all topics in Table 1 and deploy them in the classrooms. Based on the collected student data, with any necessary adjustments, we will develop all the remaining models for topics in Table 2.

Table 1 High priority topics that will be addressed during the 1st year of the project

No.	Topic	Note
1	Virtual Night Sky	See this as an example: here
2	Diurnal Motion of Celestial	Can utilize Virtual Night Sky model
3	Origin of Seasonal	Can utilize Virtual Night Sky model
4	Time & Calendar	Can utilize Virtual Night Sky model
5	Solar rotation and cycle	Split screen view (top view and Mars position)
6	Eclipses	Reproduce/predict/simulate solar or lunar eclipses

3-D models can be utilized in various ways, including interactive 3-D simulations projected into a VR headset. For instance, we can simulate solar/lunar eclipses using realistically created Sun, Earth, and Moon in accurate orbits. By interactively adjusting camera viewing angles, object sizes, orbital inclinations, etc., students can grasp the fundamental principles governing the eclipse phenomenon. Such simulations can be created with any modern 3-D engines, such as Blender, Unity, Godot, or Unreal Engine. These simulations not only enhance students' understanding of fundamental astronomy concepts but also hone their critical thinking and problem-solving abilities. Two freshman computer science majors have already begun creating the eclipse simulation module with Blender (see Figure 1). Our project has the potential to revolutionize astronomy education and significantly contribute to the open education resource community, freeing it from traditional limitations and ushering in a new era of exploration and comprehension.

Figure 1 A snapshot image rendered from a 3-D simulation of the Sun-Earth-Moon system created by Blender V3.6.2. This simulation was created by two freshmen UGA students.

A single 3-D model can be used in many related topics. For example, an accurately modeled Sun-Earth-Moon system can be used to highlight the lunar phases and libration by adjusting the aspects of the viewing camera.

Table 2 Additional astronomy topics for 3-D model creations.

No	Topic	Note
7	Precession and change of zodiacs	
8	Light pollution	weather-free public outreach events
9	Solar System Overview	
10	Doppler Effect	maybe using audio capability of a VR headset
11	Motions at the Galactic Center	
12	Retrograde motion of Mars	
13	Stellar evolution on the HRD	different speed for each mass
14	Telescope (diffraction), atmosphere	
15	Star Formation	or Simulation of Turbulent Gas
16	Latitude-dependent Shape change of	May be for upper-level astronomy courses
17	Parallax and proper motions	
18	Blackbody radiation: color and temp	BB, type of spectrum = emission, absorption
19	Cosmic scale	
20	Hubble Expansion	
21	Binary orbit: Orbital motion (and reflex	
22	Asteroids, NEA, PHA.	Good public outreach topic
23	Landing on Surfaces of SS planets	different landscape of each planet

We have completed preparatory work to gather currently available 3-D simulation development platforms and have built a database of the pros and cons of each relevant technology. Our models are curriculum/topic-driven, not limited by a single platform. This means some simulations can be efficiently created with one platform (e.g., Blender), while others are better developed with platforms that provide real-time, high-quality user interactions (e.g., Unity, Unreal Engine, or Godot). Table 3 in Appendix (before References) shows selected topics from Tables 1 & 2, with more detailed information on each model, learning objective, limitations and affordances, and recommended immersive technologies.

PI will create a detailed simulation requirement document for each topic in Tables 1 & 2 to guide student programmers during the actual development of the simulations. By the time of the announcement of the selection of this proposal, we will have identified the most suitable technology platform for each topic. Simulation requirement documents will be transformed into "storyboard" files by non-programming undergraduate students under faculty guidance, and these documents will be reviewed and evaluated in regular group meetings. Dr. Weliweriya, science education expert, will lead efforts to implement developed 3-D models into actual courses. This includes: (1) coordinating with astronomy course instructors for securing necessary IRB approvals, (2) developing student surveys, and (3) analyzing collected data.

Created simulations will be provided through the project webpage, published reports/papers, and other common OER repositories such as the OpenStax OER common. All results, including the resultant 3-D models, script files, rendered results, and relevant documents, will be made openly accessible under the Creative Commons Attribution License (CC-BY).

Three critical tasks that we will accomplish during years 1 & 2 are:

- Creating simulation requirement documents and storyboard files: This effort will be carried out by the PI. A simulation requirement document describes details of the intended simulation like a scenario for a short movie. Then, each file will be transformed into a storyboard file. We anticipate about 2 days of effort (~10 hours) per single topic.
- Developing actual simulations will be done by paid undergraduate programmers under close mentoring by the PI. As has been done previously, Drs. Song and Weliweriya will

continue announcing opportunities and recruiting capable undergraduate students among physics/astrophysics majors and engineering students. Course credits for these efforts can be formalized under the experiential learning program initiative of the host institution. Although the range of scope and depth for each simulation varies extensively, we anticipate about 30 students' hours to create one draft simulation. Experienced students can teach the next group of new students through hands-on interactive sessions and/or detailed tutorials.

- Use the created simulations in actual classroom lectures, perform prepared surveys, analyze data, and present the result.

In year 3, we will focus on publishing and sharing the project results (please see the separate "(Project) Timeline" document for details).

3.2 Quantitative and Qualitative Measures

Learning Outcomes of astronomical 3-D models:

The proposed astronomical 3-D models can offer a variety of learning outcomes.

Improved understanding of astronomical concepts: The 3-D immersive experience in our proposed immersive platform can help students better understand basic astronomical concepts (e.g., the solar system's structure) and more complex concepts such as eclipses, tides, and 3-D space motion (parallax and proper motions).

Improved critical thinking and problem-solving skills: Astronomy involves analyzing data, making predictions, and evaluating evidence. Using 3-D models, students can develop their critical thinking and problem-solving skills by exploring astronomical phenomena, interpreting data, and testing hypotheses.

Enhanced spatial reasoning skills: Astronomy involves thinking about objects and phenomena on a vast scale, often at distances and sizes that are difficult to comprehend. Students can use an immersive platform to develop their spatial reasoning skills by visualizing and manipulating astronomical objects in three dimensions.

Increased engagement with astronomy: A well-designed immersive platform can be highly engaging, motivating users to explore and learn more about astronomy. This can lead to a greater interest in astronomy and may encourage users to seek further information or resources.

Exposure to scientific research methods: Astronomy is a highly data-driven field, and scientific research methods are essential to the discipline. Using an immersive platform allows users to gain exposure to these methods, such as observing phenomena, collecting data, and interpreting results.

Asses the effectiveness of the 3D models:

In fall 2025, we will leverage students enrolled in the introductory astronomy courses (ASTR1010 [Astronomy of the Solar System], ASTR1110 [Introduction to Astronomy], and ASTR1420 [Life in the Universe]), to gauge the effectiveness of our 3-D models under various key factors.

Testing Conceptual Mastery:

Method 1: Collect pre- and post-test scores from students using established astronomical assessments such as the Test of Astronomy Standards (TOAST), Astronomy Diagnostic Test 2.0 (ADT2), and Star Properties Concept Inventory (SPCI). (URL Link). These tests will measure students' general astronomy content knowledge across topics including gravity, star and stellar evolution, evolution and structure of the solar system, seasons, scale, yearly patterns, daily patterns, and moon phases.

Method 2: Collect data using individuals or groups of students in think-aloud interviews. These interviews will be follow-ups to the user surveys we collect after each session.

Gathering User Feedback: Collect end-of-session survey questions (using established astronomical assessments like Introductory Astronomy Questionnaire [IAQ] and Astronomy Self-Efficacy survey) and follow-up think-aloud interview queries to delve into user satisfaction, learning outcomes, and potential areas for enhancement.

Measuring Engagement: Monitor student engagement by tracking the number of students accessing the immersive 3-D model(s), their session durations, and frequency of return visits. Additionally, modern VR headsets will allow us to capture eye movement data and vital indicators of user engagement. Furthermore, STEM research on students' ability to solve physics problems found that students have difficulties interpreting, constructing, and switching between representations (algebraic, gestural, graphical, and verbal). In our team's recent work on upper-division student problem-solving processes, we use students' oral exam data to look at representations at a microscopic level. We used social semiotic resources' disciplinary affordances to describe how the representations are developed, determined to be insufficient, and replaced or augmented by new ones brought in by the students [30]. Previous analysis solely depends on student reasoning and the interviewer's notes on the reason for students' thought processes. As the next step of the assessment, we will explore if we could track students' eye movements to investigate what representations or features of representations, they pay attention to while solving problems.

Comparative Assessment: Compare the 3-D model's performance with traditional classroom instruction and existing online learning modules, evaluating its 3-D graphics quality and stability.

Exploring Representation Analysis: Investigate how students interpret, construct, and switch between different representations (algebraic, gestural, graphical, verbal). By tracking students' eye movements while solving problems, we seek to understand which aspects of representations they focus on.

4 DISSEMINATION OF THE RESULT

In addition to publishing and sharing project results in conferences and research journals, we will share all developed 3-D models and related materials, such as simulation requirement documents and storyboard files, under the Creative Commons Attribution License (CC-BY).

Our project has the potential to revolutionize astronomy education and significantly contribute to the open education resource community, freeing it from traditional limitations and ushering in a new era of exploration and comprehension for all. The results of our proposed research project will not only enhance students' understanding of fundamental astronomy concepts but also refine their critical thinking and problem-solving abilities. Our project results can be readily applied to other STEM disciplines, potentially triggering a paradigm shift in general STEM education with the new immersive technologies, thereby motivating more students into the STEM fields. In fact, we have already started inter-disciplinary collaboration across multiple STEM departments & schools such as veterinary medicine, oceanography, psychology, geography, etc. Furthermore, students' in-depth involvement in developing and evaluating 3-D models provides invaluable experiential learning opportunities. They can learn details of real-time programming while contributing to the project as paid student programmers. Currently, eleven undergraduate students, four graduate students, and three high school interns are involved in the project.

By releasing our project results as openly accessible education resources, we encourage replications of our research studies at different types of institutions and with different student bodies to produce deeper knowledge about the effectiveness and transferability of findings. Our OERs can serve as useful educational materials, especially for underprivileged communities, and have high potential for broader societal impacts. For instance, broader impacts can include improved diversity of students and instructors participating in STEM education, professional development for instructors to ensure the adoption of new and effective pedagogical techniques that meet the changing needs of students, and projects that promote institutional partnerships for collaborative research and development. We will actively seek collaborators among educators at minority serving institutes. Our project is an evidence-based and knowledge-generating study aimed at understanding and improving STEM learning and learning environments, improving the diversity of STEM students and majors, and preparing STEM majors for the workforce. Our study has impacts beyond the host institution, and our project results contribute more broadly to our understanding of effective teaching and learning practices.

5 APPENDIX

Table 3. Detailed information on selected (N=10) topics for 3-D visualization.

Topic	Description & Classification	Learning Objective	2D vs. 3D - Limitations & Affordances	Recommend Platform
Virtual Night Sky	Projection of the local night sky showing named stars, constellations, and planets. Simulates local naked eye observation. Fundamentally 3D and Enhanced Viewing.	Identify key points like Polaris and constellations in the night sky to orient oneself and make further naked eye observations.	**2D:** Limited due to distortion that occurs in mapping 3D sky to 2D image which increases extraneous load. **3D:** Accurate spacing, size, and location of stars and constellations matches the real night sky. Affordance can be increased, and extraneous load decreased by adding labels to objects making them easier to identify.	VR or AR
Solar/Lunar Eclipses	Interactive 3D environment allowing motion about the environment to show several views of alignment of the Earth, Moon, and Sun during an eclipse. Fundamentally 3D, Spatially and Temporally Limited, and Enhanced Viewing.	Demonstrate the effect relative size, distance and alignment of the Earth, Moon, and Sun have on where the lunar shadows (umbra and penumbra) cross the Earth.	**2D:** Cannot demonstrate the relative positions of the Earth, Moon, and Sun while simultaneously showing the inclination of the Moon`s orbit and its shadows. Increased extraneous load due to separation of relevant information. **3D:** Reduces extraneous load by displaying each astronomical concept simultaneously. Increases disciplinary affordance by demonstrating each relevant concept in an astronomical setting.	VR

Diurnal Motion of the Sky	Projection of objects motion across the sky due to the rotation of the Earth. Fundamentally 3D, Spatially and Temporally Limited, and Enhanced Viewing.	Demonstrate the effect the rotation of the Earth has on the locations of objects in the night sky as the night progresses.	**2D:** Limited due to distortion that occurs in mapping 3D sky to 2D image which increases extraneous load. **3D:** Depicting accurate motion throughout the night sky reduces extraneous load.	VR
Origin of Seasonal Constellati ons	Simulated 3D environment showing the Earth`s orbit around the Sun with the celestial sphere projected out around the Earth-Sun system. Fundamentally 3D, Spatially and Temporally Limited	Demonstrate how Earth`s motion around the Sun changes the constellations that are visible in the night sky.	**2D:** Cannot simultaneously depict motion of Earth around the Sun and the constellations. Increased extraneous load stems from loss of spatial relationship between the night side of the Earth and the constellations. **3D:** Increased disciplinary affordance and decreased extraneous load caused by simultaneous depiction of relative locations of the Earth, Sun, and constellations.	AR or Comput er 3D Video
Solar Rotation and Cycle	Project images of the Sun into 3D to track the amount of and migration of sunspots. Fundamentally 3D, Spatially and Temporally Limited.	Demonstrate the differential rotation of the Sun, changing solar activity, and latitude dependency of solar activity.	**2D:** Limited due to distortion that occurs in mapping 3D sun to 2D image which alters path of sunspots across the surface of the Sun, increasing extraneous load. **3D:** Accurate motion of sunspots decreases extraneous cognitive load. Increased disciplinary affordance from accurate differential motion showing the Sun`s differential rotation.	AR or Comput er 3D Video
Retrograde Motion of Mars	Simulated 3D environment showing the Earth's and Mars' orbit around the Sun. Paired with night sky projection to display location of Mars in the night sky. Fundamentally 3D, Spatially and Temporally Limited	Demonstrate the effect of Earth's and Mars' orbital velocities have on the location and movement of Mars in Earth's night sky.	**2D:** Limited due to distortion that occurs in mapping 3D sky to 2D image which increases extraneous load. Difficult to simultaneously depict the relative position of the Earth and Mars, as well as the tilt of the Earth. **3D:** Accurate motion of Mars through Earth's night sky decreases extraneous cognitive load. Increased affordance by displaying Earth's axial tilt along with relative orbital velocities.	VR, AR, or Comput er 3D Video

Parallax	Interactive 3D environment facilitating simulated measurements of the positions of selected stars against background stars. Fundamentally 3D, Spatially and Temporally Limited.	Demonstrate the method for making parallax measurements and the latitude dependence of measurements.	**2D:** Inability to display parallax angle and altitude of star simultaneously leads to decreased disciplinary affordance. **3D:** Increased ability to display parallax angle and altitude of star in night sky at the same time leads to increased disciplinary affordance. Accurate motion against background stars can be depicted decreasing extraneous load.	VR or AR
Size and Scale	Visualization of the relative size and scale of astronomical objects. Spatially and Temporally Limited.	Demonstrate how astronomical objects' size varies in magnitude, and the extent of each order of magnitudes change.	**2D:** Limited space on screen decreases affordance as objects of different magnitude are difficult to display together. **3D:** Increased working area can display multiple objects of different sizes allowing for easier comparison and increased disciplinary affordance.	VR
Time and Calendar	Visualization of the orbits of Moon and the Earth relative to the Sun and the celestial sphere. Fundamentally 3D, Spatially and Temporally Limited.	Demonstrate the difference between sidereal and synodic periods and why they are different amounts of time.	**2D:** Cannot accurately display location of solar system objects and celestial sphere simultaneously, decreasing affordances. **3D:** Simultaneous depiction of solar system objects and celestial sphere increases disciplinary affordances. Accurate depiction of celestial sphere decreases extraneous load.	VR or AR
Light Pollution	Interactive night sky simulation allowing for control of light pollution level. Fundamentally 3D, Enhanced Viewing.	Demonstrate the impact light pollution has on night sky viewing conditions.	**2D:** Limited due to distortion that occurs in mapping 3D sky to 2D image which increases extraneous load. **3D:** Increased disciplinary affordance due to accurate night sky depiction paired with impact of increasing levels of light pollution.	VR or AR

(Word Count = **~4,875** words)

6 REFERENCE

1. Oliss, McFaul, & Riddick 2023, *The Global Distribution of STEM Graduates: Which Countries Lead the Way?* November 27, CSET
2. Educating the Engineer of 2020: *Adapting Engineering Education to the New Century*. National Academy of Engineering, (Washington, DC, 2005)
3. Collins et al. 1991, *Cognitive apprenticeship: Making thinking visible*, American Educator 15, 6-11, 38-46
4. Jonassen & Land 2012, *Theoretical foundations of learning environments*. (Routledge)
5. Bergstrom, Sadler, and Sonnert 2016, *Evolution and Persistence of Students' Astronomy Career Interests: A Gender Study,* Journal of Astronomy & Earth Science Education, V3, 77
6. Cole et al. 2018, *Spatial thinking in astronomy education research*, Phys. Rev. Phys. Educ. Res., 14, 10139
7. Wieman & Perkins 2005, *Transforming physics education*, Physics Today 58, 36
8. Christian and Belloni 2013, *Physlet Physics 3rd Edition*
9. Wieman 2008, *PhET: Simulations that Enhance Learning,* Science, 322, 682
10. Hake 2008, *Design-based Research in Physics Education: Review,* in Handbook of Design Research Methods in Mathematics, Science, and Technology Education (eds A.E. Kelly, R.A. Lesh, & J.Y. Baek). Routledge
11. Wilson 1994, *The CUPLE Physics Studio*, Physics Teacher 32, 518-523

12. Laws 1997, *Millikan Lecture 1996: Promoting active learning based on physics education research in introductory physics courses*, American Journal of Physics 65, 14-21

13. Belcher 2001, Studio Physics at MIT

14. Roy 2003, *Studio vs Interactive Lecture Demonstration – Effects on Student Learning*, Bioscience 29, 3-6

15. Redish 2003, *Teaching Physics With the Physics Suite* (John Willey & Sons, 2003)

16. Enderle et al. 2013, *Exploring the context of change: Understanding the kinetics of a studio physics implementation effort*, Phys. Rev. – Phys. Edu. Res. 9, 010114

17. Belloni & Christian 2003, *Physlets for Quantum Mechanic,* Comput. Sci. Eng. 5, 90

18. Wolfgang & Esquembre 2007, *Modeling Physics with Easy Java Simulations*, Phys. Teach. 45, 475

19. eSchool News by ViewSonic 2023, link to the publication

20. Kazu and Kuvetli 2023, *The Impact of Virtual Reality Technology on Student Engagement and Learning Outcomes in Higher Education,* 2nd International Conference on Recent Academic Studies, 432, 143

21. Lin et al. 2024, *The impact of virtual reality on student engagement in the classroom – a critical review of the literature,* Frontiers in Psychology, 15, 1

22. O'Connor and Mahony 2023, *Exploring the impact of augmented reality on student academic self-efficacy in higher education,* Computers in Human Behavior, 149, 107963

23. Nooriafshar, Mehryar, & Williams 2004, *The Use of virtual reality in education*, American Society of Business and Behavioral Sciences, 7th Ann. Conference

24. Shapiro & Stolz 2019, *Embodied Cognition and its Significance for Education*, Theory and research in education, 2019, v17, 19

25. Weliweriya 2019, *Investigating Students' Use of Mathematical Tools and Representations in Undergraduate Physics Problem-solving*, Kansas State University, United States -- Kansas, 2019. ProQuest,

26. Schnotz and Kürschner 2007, *Reconsideration of Cognitive Load Theory*, Educ. Psychol. Rev. 19, 469–508

27. Trumper 2000, *University students' conceptions of basic astronomy ceoncepts,* Phys. Edu. 35, 9

28. Bakas & Mikropoulos 2003, *Design of virtual environments for the comprehension of planetary phenomena based on students' ideas*, International Journal of Science Education, 25:8, 949-967

29. Blanco et al. 2019, *Lessons learned from teaching astronomy with virtual reality*, arXiv preprint arXiv:1912.12393

30. Weliweriya, Sayre, & Zollman 2018, *Case study: Coordinating among multiple semiotic resources to solve complex physics problems*, European Journal of Physics, 40, 2

SPENCER FOUNDATION

10056505 - Inseok Song, University of Georgia Research Foundation, Inc. - Proposal Budget

Salaries

	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Budget	Budget Narrative (required)
Principal Investigator (summer)	$11,632.00	$11,981.00	$12,341.00	$35,954.00	PI oversee the entire project while daily mentors a full-time graduate student involved in the project. He will create all simulation requirement documents and guide undergraduate programmers. For these effort, one summer month salary support in each year is requested.
Graduate/Research Assistant	$36,834.00	$37,939.00	$39,077.00	$113,850.00	A full time graduate student will lead the collection of classroom data, analyze them, and publish the results.
Undergraduate Research Assistant	$7,500.00	$7,500.00	$0.00	$15,000.00	About 10 undergraduate students will develop 3-D models and get paid around $12/hr.
Salaries Total	**$55,966.00**	**$57,420.00**	**$51,418.00**	**$164,804.00**	

Benefits

	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Budget	Budget Narrative (required)
PI Benefits	$2,675.00	$2,756.00	$2,838.00	$8,269.00	Benefit rate of 23% is used for the PI's salary support
Researcher Benefits	$1,473.00	$1,518.00	$1,563.00	$4,554.00	Graduate student benefit rate is 4%.
Tuition/Fees	$8,878.00	$9,144.00	$9,418.00	$27,440.00	Tuition and fee for one full-time graduate student.
Benefits Total	**$13,026.00**	**$13,418.00**	**$13,819.00**	**$40,263.00**	

Travel

	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Budget	Budget Narrative (required)
Conference or Dissemination Travel	$2,000.00	$2,000.00	$2,000.00	$6,000.00	Domestic travel to advertise and present the results. One trip by two members per year.
Travel Total	**$2,000.00**	**$2,000.00**	**$2,000.00**	**$6,000.00**	

Other Expenses

SPENCER FOUNDATION

10056505 - Inseok Song, University of Georgia Research Foundation, Inc. - Proposal Budget

	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Budget	Budget Narrative (required)
Page Charge	$0.00	$2,000.00	$2,000.00	$4,000.00	Page charges for at least two papers published in years 2 and 3.
Other Expenses Total	**$0.00**	**$2,000.00**	**$2,000.00**	**$4,000.00**	

Total Budget

	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Project Budget
TOTAL DIRECT COSTS	$70,992.00	$74,838.00	$69,237.00	$215,067.00
INDIRECT COSTS (15% MAX)	$10,648.00	$11,225.00	$10,385.00	$32,258.00
TOTAL SUBCONTRACTS	$0.00	$0.00	$0.00	$0.00
TOTAL PROPOSAL	$81,640.00	$86,063.00	$79,622.00	$247,325.00

Timeline of the Project

- Year 1
  - Jan 2025: Start of the Project
  - by Q2 2025: Finish the creation of simulation requirement documents and storyboard files for 6 selected high priority topics [IS]
  - by Q2 2025: Finish creations of in-class surveys [NJW, graduate student]
  - by Q3 2025: Finish the creation of 6 high priority topics [IS + undergrads]
  - by Q3/Q4 2025: Pilot tests of created 3-D models in class [IS/NJW/grad]
  - Q4 2025: Testing 3-D models [NJW]
- Year 2
  - Q1 2026: Present project results in conferences [IS/NJW]
  - Q1 2026: Continue testing 3-D models [NJW]
  - by Q2 2026: Create all simulation requirement documents [IS]
  - by Q1 2026: Revision of student surveys [NJW]
  - by Q2 2026: Create all storyboard files [NJW + undergraduates]
  - by Q3 2026: Publish the early result [graduate student]
  - by Q4 2026: Finish the development of all 3-D models [IS + undergrads]
  - Spring/Fall 2026: Implementation of 3-D models in astronomy courses [All]
- Year 3
  - Q1 2027: Present project results in conferences [IS/NJW]
  - Q2 2027: Organize the project results for public release [IS + graduate]
  - Q3 2027: Public release of all project files [IS]
  - Q4 2027: Preparation and submission of the final report [IS/NJW]

In the above list, IS stands for the PI (Inseok Song) and NJW stands for Dr. Weliweriya.

We will present results at prominent conferences, including AAPT (American Association of Physics Teachers) and PERC (Physics Education Research Conference). Undergraduate students will be encouraged to participate in the University's Center for Undergraduate Research Opportunities (CURO) program and present the results during the annual CURO symposium.

PROJECT TEAM

- PI (**Prof. Inseok Song**): Associate Professor of Astronomy. An observational astronomer published 150+ peer-reviewed astronomy journal articles including *Nature*, *Science*, *ARA&A*, *PNAS* articles. He will oversee the entire project while daily mentoring a full-time graduate student involved in the project. He will create all simulation requirement documents and guide undergraduate programmers.
- Unfunded Collaborator (**Dr. Nandana Weliweriya**): Senior lecturer and an education expert. Because of the University's internal rule for a lecturer listed as an investigator in external grant proposals, he is listed as an unfunded collaborator in this proposal. In fact, Drs. Song and Weliweriya co-lead the project and share 50%/50% credits for the project result (see the attached Letter of Collaboration). He will (co)-mentor graduate, undergraduate, and high school students. In addition, he will participate in the stage of (1) creating the simulations, and the activities around them - curriculum development component and (2) implementing and measuring the impact of developed simulations, and the activities around them.
- Full-time Graduate Student (**TBD**): He/she will lead the collection of classroom data, analyze them, and publish the results.
- Undergraduate students (N~10): Will develop 3-D astronomy models with a 3-D engine (Blender, Unity, Godot, and Unreal Engine 5) under the close guidance of the PI. Some (N~2) non-programming students will work on the creation of "storyboard" files.
- Highschool interns (N~10 total): Our team regularly accept high school interns from a local high school. In 2024 summer, we accepted three students who are currently developing some of the 3-D models.
- Two members of the team will present the results in conferences, Drs. Song and Weliweriya will recruit new students to work in the project, and lead the outreach activities.

UNIVERSITY OF GEORGIA

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June 17, 2024

Letter of Collaboration for Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning

Dear Grant Review Committee,

I am Nandana Weliweriya, a Senior Lecturer and education expert with a background in physics education research at the University of Georgia's Physics and Astronomy Department. I am pleased to write this letter to express my sincere commitment to collaborating on the project titled "Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning." Due to the University's internal rules for lecturers listed as investigators in external grant proposals, I am designated as an unfunded collaborator in this proposal. I work closely with the Principal Investigator, Dr. Song, and we have agreed to share credit for the project results equally.

As an unfunded collaborator, I acknowledge the importance and potential impact of this initiative and am fully dedicated to contributing to the successful completion of the proposed tasks. The significance of enhancing STEM education, particularly in the field of astronomy, using modern immersive technologies cannot be overstated. This project addresses an urgent need to attract and retain more students in STEM fields by fostering their motivation and curiosity through engaging, hands-on learning experiences.

My involvement in this project will include:

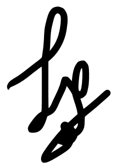
- **Developing Curriculum and Simulation Requirements:** I will assist in creating detailed simulation requirement documents and storyboard files for the identified astronomical topics. These documents will guide student programmers in the development of scientifically accurate and educationally effective 3-D models.
- **Mentoring and Supervision:** I will provide mentorship and supervision to undergraduate students involved in the creation of the 3-D simulations. This includes reviewing their work, offering constructive feedback, and ensuring the simulations meet the highest educational standards.
- **Implementation and Assessment:** I will support the integration of these simulations into the classroom, coordinate with instructors to secure necessary IRB approvals, develop student surveys, and analyze collected data to assess the effectiveness of the 3-D models in enhancing students' understanding of astronomy concepts.
- **Dissemination of Results:** I will contribute to the publication and sharing of project results through reports, presentations, and open educational resources repositories, ensuring the wider academic community benefits from our findings and innovations.

I am enthusiastic about the opportunity to collaborate on this groundbreaking project and confident that our combined efforts will lead to significant advancements in astronomy education.

Thank you for considering my collaboration in this important endeavor.

Please feel free to contact me at [nandanaw@uga.edu], if you have any questions or need further information.

Sincerely,



Nandana Weliweriya, Ph.D.
Senior Lecturer, Physics Education Researcher,

E-mail: *nandanaw@uga.edu*

Biographical Sketch

(updated on May 22, 2024)

Objective

Apply my experience/knowledge in astronomy research and education to enhance our understanding of the planet formation and evolution. This ties to one of the most fundamental questions of mankind, "Is there other life in the Universe?" and "How did we start?"

1 Personal

- Department of Physics and Astronomy
  The University of Georgia
  Athens, GA 30602-2451
- E-mail: song@uga.edu
- Phone: (706) 542-7518
- Fax: (706) 542-2492

2 Education

1994 - 2000	Ph.D.	University of Georgia
1989 - 1991	M.Ed.	Seoul National University (Korea, Science Education)
1985 - 1989	B. Sc.	Seoul National University (Korea, Earth Science)

3 Awards

2024	Fulbright US Scholar Award
2010	AAAS Newcomb Cleveland Award
2009	Ralph E. Powe Faculty Award: Oak Ridge Association of University
2005	Outstanding Young Researcher Award : Association of Korean Physicists in America (AKPA)
1999	Korean Honor Scholarship (awarded by the Korean Embassy in US)
1991	Edu. General's Award (Outstanding trainee) : The 3rd Military Academy (Korea)

4 Employment & Position History

2013 - now	Associate Professor	University of Georgia
2015 - 2018	Graduate Coordinator	University of Georgia
2008 - 2013	Assistant Professor	University of Georgia
2007 - 2008	Staff Research Scientist	IPAC / Caltech
2004 - 2007	Assistant Astronomer	Gemini Observatory
2002 - 2004	Assistant Scientist	UCLA
2000 - 2002	Post-doctoral researcher	UCLA

5 Activities and Experiences

- Age determination of field stars
- Discovery of nearby young stellar groups (e.g., TWA, Tuc/HorA, β-Pic, AB_Dor, and Columba groups)
- Infrared excess stars in the solar neighborhood

- Direct imaging search for exoplanets
- Management of huge astronomical catalogs (with $\sim 10^9$ entries) in relational databases (e.g., MySQL)
- Software developments and support for Keck/OSIRIS, Gemini/NIFS, & Spitzer/IRAC
- Associate Editor: Astronomy and Space Science (Frontier), 2023-
- Executive Committee, Gemini Planet Imager, 2010/10-2014/8
- Science Steering Committee, Gemini Planet Imager, 2010/10-2017/8
- Lead the project, STEMin3D (https://STEMin3D.net)

6 Recent Professional Highlights

Executive and Science steering committee member of the Gemini Planet Imager (GPI) Exoplanet Survey team

Discovery of young Sun analogs undergoing "Heavy Bombardments" or "Planetary Collisions" (e.g., **BD+20 307** and **HD 23514**)

Co-discoverer of **the planetary system with multiple planets in direct imaging (HR 8799)**

Co-discoverer of **the rapidly disappeared debris disk around TYC 8241 2652 1**

Co-discoverer of **the first imaged planetary mass object beyond our Solar System (2M1207b)**

Recipient of the **2010 Newcomb-Cleveland Award** which is given to the author(s) of the best paper published in Science in 2009

Over 300 nights of Optical/IR photometric/spectroscopic observing experience at Gemini, Keck, Lick, Las Campanas, Siding Spring, etc.

7 Teaching/Mentoring Experience

2015 - now	Teaching "Astronomy Lab"
2014 - now	Teaching "Astronomy Seminar"
2013 - now	Teaching "Stellar & Galactic Astronomy"
2011 - now	Teaching "First Year Odyssey Seminar"
2010 - now	Teaching "Observational Astronomy" & "Introduction to Astronomy: The Solar System" courses
2008 - now	Teaching "Life in the Universe"
2017 -2024	Advising a graduate student [David Jordan]
2020 - 2024	Advising a PhD student [Robin Allen]
2014 - 2021	Advised a PhD student [Lauren Sgro]
2013	UGA Online Learning Fellow
2013 - 2020	Advised a PhD student [Jinhee Lee]

2009 - 2022	Hosting high school Interns via UGA's Young Dawgs Program (10 students to date)
2008 - 2013	Advised a PhD student [Adam Schneider]
2010 - 2016	Advised a PhD student [Tara Cotten]
2016 - 2022	Teaching "Introduction to Scientific Programming, Data Analysis, and Visualization for Physicists"
2008 - 2010	Advised MS student [Ben Ruskin]
2007 - 2011	PhD Supervisory committee member for Simon Murphy (Australian Nat'l Univ.)
2006 - 2009	mentored a UCLA PhD student (Carl Melis)
2004 - 2007	mentored two post-docs and two intern students at Gemini

8 Service

Professional

- Referee & Peer Review : serving regularly as a referee for major journals (ApJ, MNRAS, AJ, A&A, Astron.Note, Nature, Science, etc.), grant proposals (both national and international), NASA Post-doctoral Program, and Telescope Time Allocation Committees (NASA/Keck, NOIRlab, K-GMT).
- International conference organizing committee member (LOC): IAU 314, Atlanta, GA (2015)

University Service

2015 - 2016	Chair of the Executive Committee at Franklin Faculty Senate
2013 - 2016	Franklin Faculty Senate
2015, 2017	UGA Faculty Research Grant review
2015 - present	Reviewers for several University-wide award competitions: Dissertation Completion Awards, Graduate School Research Assistantship, Presidential Scholarship, Carmen Scholarship, Innovative and Interdisciplinary Research Grants, etc.

Department Service

2023 - now	Interim Associate Head
2022	Planning & Development, Graduate admission, Website, Grad. curriculum (Chair)
2021	Planning & Development, Graduate admission, Website, Grad. curriculum (Chair)
2020	Planning & Development, Graduate admission, Website, Grad. curriculum (Chair), Post-tenure-review (K. Nakayama)
2019	Planning & Development, Graduate admission, Website, Grad. curriculum, Post-tenure-review (C. Wiegert)
2018 - 2019	Chair of the Search Committee for Computational Astrophysicist
2018	Committees: Dept. Website, Graduate curriculum,

2015 - 2018	Graduate Coordinator, Department of Physics & Astronomy, Planning & Development, Assessment
2017	Committees: Colloquium, Planning & Development, Graduate admission, Assessment, Post-tenure-review (Q. Zhao)
2016	Committees: Colloquium, Planning & Development, Graduate admission, Graduate curriculum, Assessment
2015	Committees: Colloquium, Planning & Development, Graduate admission, General & graduate faculty secretary, Post-tenure-review (W. Dennis)
2014	Committees: Colloquium (Chair), Planning & Development, Graduate admission, General & graduate faculty secretary
2013	Committees: Newsletter, Graduate curriculum, Undergrad recruitment, Graduate admission, Prelim exam
2012	Committees: Newsletter, Prelim exam, Graduate Curriculum, Undergrad recruitment
2011	Committees: Newsletter, Prelim exam
2010	Committees: Undergrad recruitment & public relation, Prelim exam, departmental webpage

9 Current and Former Students

Adam Schneider (PhD, USNO staff), Tara Cotten (PhD, lecturer at UGA), Jinhee Lee (PhD, post-doc KASI), Lauren Sgro (PhD, post-doc SETI), Ben Ruskin (MS, high school teacher), Simon Murphy* (PhD, Univ. of New South Wales astronomer), Adric Riedel* (PhD, STScI software engineer), David Jordan (MS), Robin Allen (MS)

10 Research Grants

About 1 million USD from 30+ grants as PI and co-I since 2000.

11 Publications (chronological order)

More than 140 peer-reviewed articles. See the list of publications from `https://ui.adsabs.harvard.edu/public-libraries/Y--oWzCHRZWEu6OcntgbLg`

12 Grant Proposal Submission History (past 3 years)

Grant proposal (internal and external) submission history over the past 3 years

Title: Enhancing Student Understanding through Immersive Astronomy Open Education Resources
Project Period: 05/01/2024 – 06/31/2024
Funder name: UGA
Proposed award amount: $29,996
Status: funded (PI)

Title: Empowering Experiential Learning: A Hands-On Game Engine Programming Initiative for Engineering Majors

Project Period: 02/01/2024 – 06/31/2024
Funder name: UGA
Proposed award amount: $4,000
Status: funded (co-PI)

Title: Adoption of the free OpenStax textbook for multiple astronomy courses
Project Period: 02/01/2024 – 06/30/2024
Funder name: UGA
Proposed award amount: $5,000
Status: funded (PI)

Title: Teaching Enhancement and Innovation Fund for FY24
Project Period: 02/01/2024 – 06/30/2024
Funder name: UGA
Proposed award amount: $2,000
Status: funded (co-PI)

Title: Exploring Virtual Reality in Astronomy Education: Enhancing Student Understanding through Immersive Learning Environments
Project Period: 07/01/2023 – 06/30/2024
Funder name: UGA
Proposed award amount: $25,000
Status: funded (co-PI)

Title: Exploring Virtual Reality in Astronomy Education: Enhancing Student Understanding through Immersive Learning Environments
Project Period: 07/01/2023 – 06/30/2024
Funder name: UGA
Proposed award amount: $25,000
Status: funded (co-PI)

Title: Enhancing ASTR 1420 Course with an OpenStax textbook
Project Period: 02/01/2022 – 06/30/2022
Funder name: UGA
Proposed award amount: $5,000
Status: funded (PI)

Title: Presidential Interdisciplinary SEED grants
Submitted date: July 2023
Funder name: UGA
Proposed award amount: $100,000
Status: Not funded (co-PI)

Title: SEarch for Nearby Stars with Extreme Excess Emission: SENSE3
Start date: 1 September 2023
End date: 31 August 2025
Funder name: NATIONAL AERO & SPACE ADMIN
Proposed award amount: USD 191,857
Status: Not funded (PI)

Title: Building the Nearby Young Stars ARChive: NYSARC
Start date: 1 September 2023
End date: 31 August 2026
Funder name: NATIONAL AERO & SPACE ADMIN
Proposed award amount: USD 458,450

Status: Not funded (PI)

Title: SED/Emcee Characterization of transiting exoplanet host stars
Start date: 1 January 2023
End date: 31 December 2025
Funder name: NATIONAL AERO & SPACE ADMIN
Proposed award amount: USD 306,641
Status: Not funded (PI)

Title: Building or destroying? Distinguishing between models for the origin of material orbiting the dustiest main sequence stars
Start date: 1 January 2022
End date: 31 December 2024
Funder name: NATIONAL AERO & SPACE ADMIN
Proposed award amount: USD 207,952
Status: Not funded (PI)

Title: Building or destroying? Distinguishing between models for the origin of material orbiting the dustiest main sequence stars
Start date: 1 July 2021
End date: 30 June 2024
Funder name: NATIONAL SCIENCE FOUNDATION
Proposed award amount: USD 207,952
Status: Not funded (PI)