UNIVERSITY OF GEORGIA

Franklin College of Arts & Sciences
Department of Physics & Astronomy
201 Cedar Street
Athens, Georgia 30602-2451 U.S.A.

TEL 706-542-2485 | FAX 706-542-2492
physast.uga.edu

PROJECT STATUS REPORT: 02/01/2024

EXPLORING VIRTUAL REALITY IN ASTRONOMY EDUCATION: ENHANCING STUDENT UNDERSTANDING THROUGH IMMERSIVE LEARNING ENVIRONMENTS

Nandana Weliweriya & Inseok Song (Physics and Astronomy)

Introduction:

This project, designed to enhance the quality of astronomy instruction and research across STEM disciplines, addresses current limitations in astronomy lab courses. By offering students a dynamic tool to engage with real-world scenarios, the VR platform aims to cultivate essential problem-solving and decision-making skills.

Dr. Inseok and I have played integral roles in steering the STEMin3D project's remarkable growth, witnessing active participation from approximately **10 faculty members** and **15 students** (graduate and undergraduate). Our interdisciplinary research team brings together seasoned faculty members specializing in astronomy, education research, big data, and artificial intelligence. With expertise in Virtual Reality and Multimodal 3D User Interfaces, virtual reality teaching platforms, and adept STEM instructors, our team is well-equipped to advance our objectives.

The essence of this project proposal aligns seamlessly with UGA's 2025 Strategic Plan, particularly in the domains of 'Promoting Excellence in Teaching and Learning' and 'Growing Research and Innovative Approaches to Teach and Create Research Opportunities.' Furthermore, our project harmonizes with the core themes of the Presidential Interdisciplinary Faculty Hiring Initiative in Data Science and Artificial Intelligence, emphasizing the translation of education research into health professions and STEM disciplines.

Below, we summarize the progress that we acquired thanks to CTL's Learning Technology Grants (LTG) support.

Equipment Purchase: As per the proposal to purchase, significant progress has been made in acquiring essential equipment for our project:

- We have successfully obtained the new Meta - Quest Pro, a substantial upgrade from the previous pico neo eye 3 we were using.
- The next crucial addition is a high-performance workstation tailored to meet the demanding programming requirements of the project. The workstation specifications include an i9 12900KF processor overclocked to 5.2GHz with 16 cores, Windows 11 Pro, 64GB RAM, a 1000GB NVMe 4.0 SSD, a Quadro RTX A4000 GPU, and a 10TB RAID storage.
- Additionally, we have secured the domain name for the project: `STEMin3D.net`. Further developments related to the website are outlined below.

Student support: As per the proposal to support students,

- Graduate student Robin Allen received full support for the fall 2023 semester and is currently on partial support for the spring semester. Robin plans to complete his MS degree by the end of May.
- Freshman undergraduate students Emre Alia and Ridwan Haque began receiving payment starting in the latter part of the fall semester, and this support will continue until the end of the grant period.
- Furthermore, we are pleased to welcome 5-6 new undergraduate students who have recently joined the project, bringing fresh perspectives and enthusiasm to our team. As we continue our efforts, we plan to identify additional undergraduates to support, leveraging the remaining funds from this grant.

Designated Working Space and update on Website

Working space: The undergraduate students on our team are actively involved in coding for the development of topic-based basic simulations. In the current and upcoming phases, they will be tasked with working on more intricate modules and converting them into simulations with user interactivity, enabling changes in some aspects of simulations in real-time. To support this endeavor, the PI and the CO-PI are actively applying for internal and external research grants to secure a workstation with high computing power, as the current equipment has limitations. This new setup will enable students to log in physically or remotely, allowing them to continue working on their projects. In the image below, you can see the current state of the computers and the workstations ready for students to use in a designated room within the physics building. The intention is to create a welcoming environment for students involved in this project, providing a space to collaborate on coursework-related tasks and work on their individual projects. The goal is to foster a sense of community and productivity within this dedicated workspace.

Update on project website: With the invaluable support from LTG's funding, we successfully launched a live website to showcase our project. The website has gained significant traction, attracting approximately 500 visitors per month. We are eager to maintain this momentum and ensure continuous support for the website's functionality and content. Dr. Song collaborated with the university's EITS to initiate an enterprise GitHub account specifically for the project. This initiative provides us with unlimited space to add and store student projects, accompanied

by version control mechanisms to prevent potential data loss. As a notable outcome, the project has now obtained an official myID and UGA.edu email address, enhancing our capacity to collaborate with external partners and stakeholders. This strategic move aligns with our vision for broader outreach and engagement.

Student presentations and Achievements

- Graduate student Robin Allen's work was highlighted in the recent presentation titled "Enhancing Astronomy Education: Demonstrating Astronomical Phenomena using Immersive 3D Learning Experiences Motivation" at the 90th Annual Meeting of the APS Southeastern Section, held at Eastern Kentucky University (November 9-11, 2023). The presentation is documented in the following publication: "DOI: 10.13140/RG.2.2.23135.02721" - and attached at the end of this document.
- The undergraduate students, Emre Alia, Ridwan Haque, Max Baxley, and Gioia Zincone, have applied for the spring CURO assistantship awards to continue their work on individual projects, and we are pleased to announce that all of them have been awarded the CURO assistantship. This recognition not only acknowledges their dedication and contributions but also provides them with the support needed to further excel in their respective projects during the spring semester. We are excited about the continued progress and success of these talented students in their research endeavors.

Plans for the rest of the academic year

- Graduate student Robin Allen has submitted his application to obtain IRB approval for collecting data using commercially available VR teaching resources. This study aims to identify limitations observed by instructors and graduate teaching assistants. Beyond contributing to Robin's completion of his MS degree by the end of May, this research serves a dual purpose. It not only aids in addressing limitations promptly but also enhances the quality of simulations and activities developed over time.
- Our dedicated undergraduate students, Emre Alia, Ridwan Haque, Max Baxley, and Gioia Zincone, are actively immersed in their respective projects. Their progress is promising, and we anticipate successful presentations at this year's CURO symposium.

Additional funding opportunities

- **Pending:** The PI and the Co-I applied and waiting to hear the desions for the internal funding opportunities below,

  EETI Augmented, Remote, and Virtual Experimentation Grants, Engineering Education Transformations Institute (EETI), College of Engineering, University of Georgia, 2024.

  2024 Active Learning Change Grants

  Provost's Affordable Course Materials Grant - AY 24
- **Rejected:** The PI lead a multidsciplinary grant proposal for the 2023 Presidential Interdisciplinary Seed Grant Program, but it was declined.
- **Future:** As we set our sights on major external funding opportunities from esteemed agencies such as NSF/IUSE, NSF/AISL, Unreal Engine Epic Mega grant, NASA/MUREP, and others, the engagement of undergraduate students in programming and simulation design lends a unique dimension to our project. The establishment of a dedicated office space, complete with powerful computers, further fortifies our position in the pursuit of external grants.

Summary and Acknowledgment:

In conclusion, the past few months have witnessed the rapid growth and surpassing of milestones by our project, exceeding initial expectations. We extend our sincere gratitude to the Center for Teaching and Learning at the University of Georgia for their unwavering financial support, which has been instrumental in our success.

As we reflect on our journey, we anticipate submitting a comprehensive final report by the end of the semester, encapsulating the valuable achievements and highlighting the positive impact of this collaboration. We remain committed to advancing education and research, and this success is a testament to the strength of our partnerships and shared dedication to excellence.

Nandana Weliweriya, Ph.D.
Assistant Professor
Physics Education Researcher
E-mail: *nandanaw@uga.edu*

Department of Physics and Astronomy
Franklin College of Arts and Sciences
UNIVERSITY OF GEORGIA

Enhancing Astronomy Education: Demonstrating Astronomical Phenomena using Immersive 3D Learning Experiences

Robin Allen[1], David Seiden[1], Nandana Weliweriya[1], Inseok Song[1]
Robin.Allen@uga.edu, David.Seiden@uga.edu, Nandanaw@uga.edu, Song@uga.edu
University of Georgia[1]

Motivation:

Current astronomy resources are limited:

- 2D Illustrations of fundamentally 3D phenomena are not adequate.
- Visualization issues lead to misconceptions (e.g., Engstrom 1991).
- Blackboards, handouts, etc. cannot accurately capture astronomical scales.
- Celestial sphere difficult to accurately portray in 2D.
- Partial illumination of spherical bodies is impossible to draw on a board.

Figure 1: Screenshots of the Moon from the Star Chart VR application. Taken from different angles to illustrate the impact of location and shape on the witnessed illumination.

Example AR Simulation:

Figure 2: Image taken from sample AR simulation, to see this simulation in use scan the QR code. AR simulation developed by project team member Shameer Abdeen.

Limitations of Existing 3D Options:

Currently the availability of 3D astronomy software is limited, with few open-source options or resources that have been tailored for use in an undergraduate setting.

- Stellarium™: Main shortfall is the lack of projection to 3D hardware such as VR headsets.
- Universe Sandbox™ and SpaceEngine™: Not accessible in a classroom setting due to reliance on high quality graphics cards and requires commercial licensing.
- Star Chart™ : Omits astronomically significant details like the celestial sphere and requires commercial licensing.

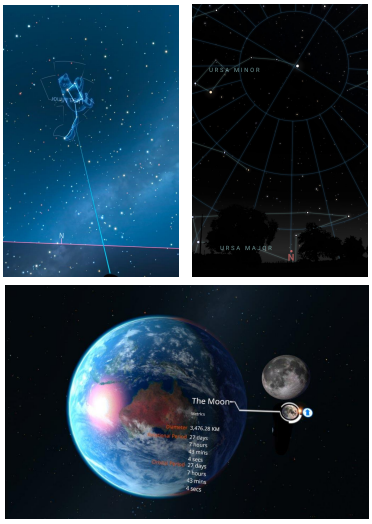

Figure 3: Sample images from Stellarium™ (top right) and Star Chart™ (top left and bottom). Top images show northern night sky from Athens GA. Bottom image shows partial illumination of the Earth.

Initial Phase:

The initial phase involves two commercially available 3D astronomy applications, SciVR and Star Chart.

- Use Star Chart™ to determine the efficacy of commercially available astronomy VR software.
- Use SciVR's (Kersting et al.) Solicit feedback on 3D tools in two different methods: 'Smart Window' and VR.

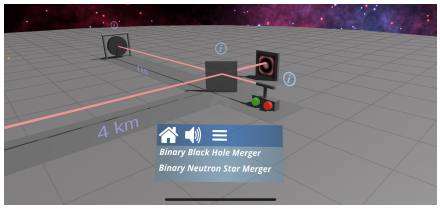

Figure 3: Sample from the LIGO function in the SciVR app.

Subsequent Phase:

Once feedback from the initial phase is compiled and reviewed new 3D learning experiences will be created for chosen 3D relevant topics. Topics include:

- Due to their inherent 3D nature: Mechanisms behind eclipses, tidal forces, and precession of the Earth
- Due to the difficulty in accurately depicting the phenomena: Projection of the celestial sphere onto the night sky, diurnal motion, and the astronomy behind the calendar

Figure 4: (left) Team member Robin Allen using Star Chart™ to explore the solar system. (right) Scan the QR code for more information on this project

References:

Yrjö Engeström, Non scolae sed vitae discimus: Toward overcoming the encapsulation of school learning, Learning and Instruction, Volume 1, Issue 3, 1991, Pages 243-259, ISSN 0959-4752, https://doi.org/10.1016/0959-4752(91)90006-T.

Magdalena Kersting, Jackie Bondell, Rolf Steier & Mark Myers (2023) Virtual reality in astronomy education: reflecting on design principles through a dialogue between researchers and practitioners, International Journal of Science Education, Part B, DOI: 10.1080/21548455.2023.2238871

Funding Provided By: Center for Teaching and Learning, UNIVERSITY OF GEORGIA

Project Team

Faculty Members

UGA - Franklin College of Arts and Science, Physics & Astronomy Department

Nandana Weliweriya
Team Lead
nandanaw@uga.edu

Inseok Song
Team Co-Lead
song@uga.edu

Cassandra Hall
Astronomy co-Lead
cassandra.hall@uga.edu

Loris Magnani
loris@uga.edu

Nicolas Young
nicholas.young@uga.edu

UGA - College of Engineering

Kyle Johnsen
kjohnsen@uga.edu
Engineering

Siddarth Savadatti
sidsavad@uga.edu
Engineering

UGA - College of Veterinary Medicine

Ania Majewska
majewska@uga.edu
Phsyiology & Pharmacology

GSU - Physics & Astronomy Department

M. Shameer Abdeen
mabdeen@gsu.edu

Graduate Students:

Robin Allen
robin.allen@uga.edu
Physics Department

Zainil Charania
zainil.charania@uga.edu
Physics Department

Brook Boe Bowers
Brook.Bowers@uga.edu
Engineering

Anton Franzluebbers
anton@uga.edu
Engineering

Undergraduate Students

David Jacob Seiden
david.seiden@uga.edu
Physics Department

Morgan Alexis Pickett
morgan.pickett@uga.edu
Physics Department

Ridwan Haque
ridwan.haque@uga.edu
Engineering

Maxwell Baxley
maxwell.baxley@uga.edu
Data Science

Gioia Zincone
gioia.zincone@uga.ed
Astrophysics

Aiden Hammond
Aiden.Hammond@uga.edu
Physics Department

Michael Cai
Columbia University

Ricky Correia
Ricky.Correia@uga.edu

Emre Aliya
ealiya2018@gmail.com
Engineering

Do you want to join?

High School Interns

Do you want to join?

Current & Pending Funding

Accepted

- 2023 Learning Technology Grant ($25,000):
  - accepted/updated proposal
  - On 09/21/2023, we requested a change in the budget.
- Teaching Enhancement and Innovation Fund for FY24: $8,000 awarded (to buy telescopes)
- 2023-24 EETI Research and Innovation Grants ($1,200?)
  - click here for the announcement
  - accepted proposal
- EETI College of Engineering 2021
- CTL's learning technologies grant (LTG) 2021
- Affordable Materials Grant, University System of Georgia, 2022

Pending

- 2023 UGA SEED grant : click here
- Round 24 of USG's Affordable Materials Grants (PI=Song, $30k)
  - RFP here, due by Oct. 30, 2023,
  - Announcement by Dec 1, 2023

Current Projects

The proposed team research initiative consists of mainly three interconnected projects aimed at enhancing instructional quality in STEM education and measuring their impact. The first project focuses on improving pre-lecture videos by integrating near and far transfer questions, promoting active engagement and deeper understanding. The second project explores the use of virtual reality (VR) to enhance astronomy education through immersive experiences, addressing limitations of traditional labs and enabling better student engagement and understanding. The third project integrates VR technology with telescopes and microscopes, creating virtual labs and training experiences to overcome equipment limitations and enhance science education. These projects aim to increase accessibility, cost-effectiveness, engagement, and research potential in STEM education by leveraging technology. The team will collaborate to develop VR simulations, training modules, and collect data for analysis to refine teaching strategies.

Click “Projects” menu at the top navigation panel for more detailed information.

To Prospective Students...

If you are interested in this project, contact Dr. Weliweriya or Dr. Song.
We welcome graduate and undergraduate students with a strong interest in STEM education. If you have good programming skills and are looking for a research opportunity in creating 3D simulations, come and talk to us.