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 REPORT: 08/29/2024

EMPOWERING EXPERIENTIAL LEARNING: A HANDS-ON GAME ENGINE PROGRAMMING INITIATIVE FOR ENGINEERING MAJORS

Nandana Weliweriya & Inseok Song (Physics and Astronomy)

Introduction:

This ongoing 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.

Below, we summarize the progress that we acquired thanks to EETI Grants support. As per the EETi proposal, we requested funds to support research team. At the same time, we Incorporated the funds reserved through the CTL's learning technologies grant,

Equipment Purchase: As per the LTG 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. Further with the support of Teaching Enhancement and Innovation Fund, Franklin College of Arts and Sciences, we added a few more VR heads sets.
- 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 EETI proposal to support students,

- Using both LTG and EETI grats, freshman undergraduate students Emre Alia and Ridwan Haque began receiving payment starting in the latter part of the fall 2023semester, and this support continued until the end of the grant period.
- Furthermore, 5-6 new undergraduate students 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, upcoming 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 **1000** 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

- 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.
- The undergraduate student Gioia Zincone received the CURO Summer Research Fellowship to continue on her project.
- Graduate student Robin Allen, currently an academic division officer at US NAVY defended his MS. thesis and the report can be found here: (`https://www.researchgate.net/publication/375633052_Enhancing_Astronomy_Education_Demonstrating_Astronomical_Phenomena_using_Immersive_3D_Learning_Experiences_Motivation`)

Current state of the simulations and future plan

- In addition to involving graduate and undergraduate students, we have also expanded opportunities for high school students at Gwinnett School of Mathematics, Science, and Technology. During the summer of 2024, three students participated in our project, and one more joined us during the fall semester.
- With the support of both current and newly joined students, we have 2-3 simulations and associated activities nearly ready for classroom rollout. In addition to these activities, the research team plans to gather student feedback through surveys and think-aloud interviews. Below is a brief update on our simulation progress.

  Eclipse simulation is dentified as a key priority and proposed as one of the initial modules. Ridwan Haque and Emre Aliya; two freshman computer science majors already started the creation of the eclipse simulation module with Blender. Their work was displayed during the 2024 CURO Symposium (`https://STEMin3D.net/results/presentations`). As picked up by the high school students and the new undergraduate student Jack Armstrong (at Vanderbilt) the deployment and testing of the soon-to-be fully developed eclipse 3-D model are planned within courses such as Astronomy of the Solar System (ASTR 1010) and Introductory Astronomy for Majors I (ASTR 1110) in the upcoming spring 2025 semester.

  Virtual Night sky: recognized as another high priority topic. Michael Cai, who joined the research team as a high school student and has continued to contribute significantly as a main program developer, even now as a freshman at Columbia University is working on his project to simulate a realistic night sky in Blender.

Broadening Research Spectrum

- The project leads successfully established significant collaborations beyond the fields of physics and astronomy, exploring topics beyond our initial suggestions. As part of this initiative, the Principal Investigators are leading one of the 2024-2025 Faculty Learning Communities (FLC) focused on Immersive Technologies. The goal of this FLC is to unite practitioners from across campus to foster interdisciplinary discussion and collaboration on utilizing immersive technologies for teaching and research.

Funding opportunities beyond EETI

- **Funderd:** The PI and the Co-I applied and recceived funds from the internal funding opportunities below,

  FY 24 - Learning Technologies Grant, UGA's Center of Teaching and Learning

  2024 Active Learning Change Grants

  Affordable Leaning Georgia gant - AY 24

- **Rejected:** The PI lead a multidsciplinary grant proposal for the 2023 Presidential Interdisciplinary Seed Grant Program, but it was declined.

- **Pending:**

  (IUSE: EDU) Improving Undergraduate STEM Education: Directorate for STEM Education - NSF 23-510

  (*Beyond Boundaries: Harnessing Immersive Environments for Elevated STEM Understanding in Education.*)

  Spencer Foundation: Large Research Grants on Education Program

  (*Enhancing Astronomy Education with Immersive Technologies and Promoting Active Learning*.)

Summary and Acknowledgment:

In conclusion, the past few semesters have witnessed the rapid growth and surpassing of milestones by our project, exceeding initial expectations. We extend our sincere gratitude to the Engineering Education Transformations Institute in the College of Engineering 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, Inseok Song
Physics and Astronomy

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.

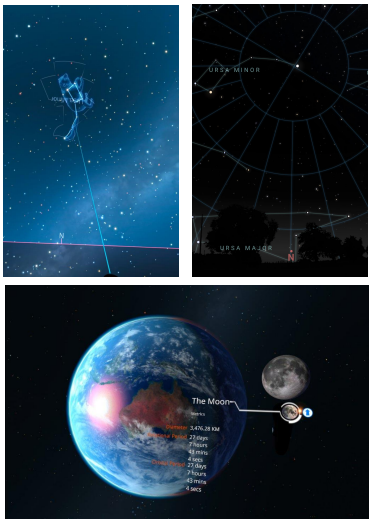


Figure 3: Sample images from Stellarium™ (top right) and Star Chart™ (top left and bottom). Top images show northern night sky from Athens GA. Bottom image shows partial illumination of the Earth.

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.

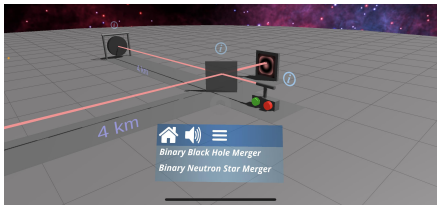


Figure 3: Sample from the LIGO function in the SciVR app.

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
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.edu
Astrophysics

Aiden Hammond
Aiden.Hammond@uga.edu
Physics Department

Michael Cai
Columbia University

Ricky Correia
Ricky.Correia@uga.edu
Computer Science

Emre Aliya
emre.aliya@uga.edu
Engineering

Nick Linkowski
nicholas.linkowski@uga.edu
Engineering

Anna Dmitrieff
annasophia.mehta@uga.edu
Physics Department

Jack Armstrong
ja2195@columbia.edu
Columbia University

Do you want to join?

High School Interns

Nisa Charania
nisacharania27@gmail.com
GSMST

Raghav Sharma
usa.raghav.sharma@gmail.com
GSMST

Opeoluwa Oyerinde
opemoyerinde@gmail.com
GSMST

Potential Collaborators

```
Katy Smith (klaustin@uga.edu): Marine Extension and Georgia Sea Grant | Water Resources Specialist
```

To Prospective Students...

If you are interested in this project, contact us at STEMin3D@uga.edu.
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. If you do not have 3-D programming experience but are willing to learn it, we can start with a small task (there are many!!)

> for you. If you are not into programming yet interested in this project, there are project tasks that are not related to programming such as student data acquisitions and analyses, developing course activities with 3-D models, etc.

This project is supported by

Affordable Learning Georgia

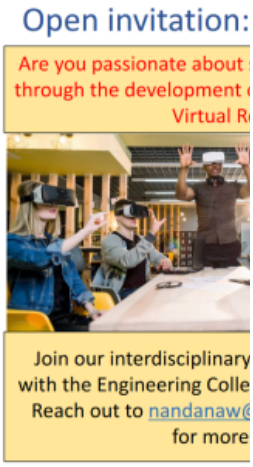
Center for Teaching and Learning
UNIVERSITY OF GEORGIA

UNIVERSITY OF GEORGIA
Active Learning

Engineering Education Transformations Institute
UNIVERSITY OF GEORGIA

Student Works

Anna Dmitrieff's Story



1
2
3
4
5
6
7
PrevNext

Showcases of undergraduate student works.

Current Projects

The proposed team research initiative consists of mainly four interconnected projects (and one active-learning project) 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 the 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. The fourth project is a platform building project that support the adoption of extended reality (XR) across the STEM discipline. Lastly, the fifth project focuses on the promotion of active learning and experiential learning environment especially in the astronomy labs. In this project, we currently build curriculum activities with low-cost (<$100) telescopes. 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.

Current/Past Funding

Awarded

Proj Period	Program Name	PI	Grant Amount
FY24/25	**Office of Active Learning**	Song/Weliweriya	$18,500
FY25	**Faculty Learning Community**	Song	$600
AY24	**Affordable Learning Georgia, Round25**	Song	$29,996
AY24	**EETI Research and Innovation Grants**	Weliweriya	$4,000
AY24	Provost Affordable Course Material	Song	$5,000
AY24	Provost Affordable Course Material	Weliweriya	$5,000
FY24	Teaching Enhancement and Innovation Fund	Hall,Song,Weliweriya	$8,000
FY24	Teaching Enhancement and Innovation Fund	Weliweriya, Song	$2,000
FY23	Affordable Course Materials Grant, Provost Office	Song	$5,000
FY23	Learning Technology Grant	Weliweriya	$25,000
FY23	EETI Research and Innovation Grants	Weliweriya	$1,200
FY22	Affordable Course Materials Grant, Provost Office	Song	$5,000
FY22	Affordable Course Materials Grant, Provost Office	Weliweriya	$9,700
FY21	EETI Research and Innovation Grants	Weliweriya	$1,200
FY21	Learning Technology Grant	Weliweriya	$25,000
FY19	Affordable Course Materials Grant	Song	$5,000
FY19	Affordable Learning Georgia Round14	Song	$20,800

Total funding (since 2019) = $170,896

This project is supported by

Affordable Learning Georgia

Center for Teaching and Learning
UNIVERSITY OF GEORGIA

UNIVERSITY OF GEORGIA
Active Learning

Engineering Education Transformations Institute
UNIVERSITY OF GEORGIA