SPENCER FOUNDATION

#10056505, Song/University of Georgia Research Foundation, Inc.

Review Form Rating Scale:
4-Strongly Agree
3-Agree
2-Disagree
1-Strongly Disagree

Reviewer 1 Comments:

Significance of the Project

3-Agree - The proposed research is focused on topics or issues related to learning or education, broadly conceived.
2-Disagree - The topics or issues are critical to the field.
2-Disagree - The research questions and/or direction of inquiry are clear and compelling.

Significance Comments:
This proposed project aims to develop 3D astronomy models that would be used as VR and AR technology tools during astronomy learning experiences in introductory undergraduate astronomy courses. The proposal suggests that current visualization and modeling used in astronomy courses is limited due to its 2D representation of complex phenomena that are challenging to envision. The proposal contains numerous assertions about the importance of such technology for astronomy education and for promoting students' interests and entry into STEM careers; however, claims made throughout the proposal are not substantiated with relevant research evidence from scholarship in STEM education. I will speak to this in more detail in the comments below.

Connection to Research and Theory

1-Strongly Disagree - Relevant research literature is used effectively in the proposal to justify the proposed work.
2-Disagree - Theory is used to explain how the proposed research will contribute to or challenge current understandings of education.

Connection to Research and Theory Comments:

While there is a rich body of research about the roles that scientific models, representations, and the practice of constructing and revising models can play for students' learning of complex phenomena, this proposed project is not building on that research literature as a basis for its work. A suggestion for the research team is to spend time examining the existing scholarship from STEM education researchers about the role of scientific modeling and representations of phenomena in supporting science teaching and learning. In future proposals, I also suggest that the research team use findings from STEM education research as evidence to strengthen and support claims made throughout the proposal. For example, the proposal contains many claims such as, "Enhancing STEM and astronomy education with modern approaches is imperative." (p. 4). However, the proposal does not explain why this enhancement is imperative nor does it offer grounding in existing evidence from STEM education research about the benefits and challenges of particular approaches for STEM and astronomy education. Similarly, the proposal is not well-grounded in a theoretical framework about how 3D representations and models might make a difference for aspects of students' astronomy learning experiences. The proposal mentions two theoretical constructs -- cognitive load theory and social semiotics -- but does not explicitly connect the design of the 3D simulations or the proposed plan for research to these two theoretical constructs. This means that any findings from the research activities -- such as improvements seen between pre- and post-assessments -- will not be meaningful in terms of contributing to on-going theorizing about student learning in astronomy.

Research Design

3-Agree - Context or research sites, as well as potential study participants including access and sampling approaches (when appropriate), are sufficiently well-described.
2-Disagree - Sources of data and/or collection plans are clearly identified and well justified.
1-Strongly Disagree - Analytic methods are clearly stated and it is evident how the data will be used to answer the proposed research questions and/or support the direction of inquiry.

Design Comments:
The proposed study would take place in large undergraduate introductory astronomy courses at the research team's university. No further details are provided regarding sampling or regarding steps taken to ensure some systematicity, multiple perspectives, and representation for think-aloud interviews. The bulk of data collection seems to focus on administering many different pre- and post-tests and survey measures. Interviews are framed as user feedback and user satisfaction rather than as research activities and click-tracking, eye movement tracking, and analytics such as time spent accessing a particular 3D model are also included but not fully explained as research activities. It is not clear to me how this research approach would yield insights into how or why different astronomy representations and models provide support for learning. In fact, I am very worried that the research team is on a path to draw some unwarranted conclusions from the pre-/post- data that are not justified by the study design. It is very challenging to gather evidence about how one adjustment to a course is or is not supporting student learning and the research team will need to consult with experts in educational measurement with experience leading randomized controlled trials in order to design studies that would be able to yield such evidence.

Dissemination Plans:
The project team plans to share their findings and their tools in traditional academic publications and presentations. They also plan to share their 3D representations/models as open-access educational materials, but they do not specify where these would be shared.

Budget and Timeline Comments:
The budget focuses on funding effort from the PI and a graduate student as well as a small team of undergraduate students paid to develop 3D models. While the budget for the PI and graduate student is appropriate, the compensation for the team of undergraduate students seems insufficient ($12 per hour for their expertise seems low to me). A collaborator is included throughout the proposal and the budget justification and project team description includes information about university rules require that a person with an appointment as a lecturer cannot be funded as a research collaborator. This is clearly explained in the proposal but is unfortunate as it seems that the collaborator is doing substantive work to contribute to all aspects of the project. The timeline for the project does not include specific details about 3D model design and development nor does it communicate about how pre-post tests, surveys, interviews, and learning analytics data would be coordinated and analyzed/interpreted.

Potential of the Research Team Comments:
The PI and Co-PI have expertise in astronomy and physics as scientists and instructors. The team does not include someone with experience and expertise in the kinds of educational research and design of educational materials that this proposal aims to do.

Recommendation Comments:
This proposed project aims to develop 3D VR and AR tools that provide representations and models of complex astronomical phenomena to support astronomy education. The project references a few related efforts within the astronomy and physics education communities, but it is not otherwise grounded in the vast body of research literature in STEM education about the roles that representations, models/modeling, and scaffolding can play in science teaching and learning. The project similarly references two theoretical constructs (cognitive load theory and social semiotics) but does not deeply connect to these theories in either the design of the 3D tools or the proposed plan for educational research. Challenges are also visible in the design of educational research where the proposed plan for research is under-developed and unlikely to yield meaningful findings given the design of the study and the lack of connection to a theoretical framework. In order for this project to be successful as an educational research endeavor, I highly recommend that the project team work with educational researchers including at least one researcher in STEM education with expertise in the role of scientific modeling in student learning and one researcher with expertise in educational assessment and measurement of learning.

Reviewer 2 Comments:

Significance of the Project

4-Strongly Agree - The proposed research is focused on topics or issues related to learning or education, broadly conceived.
3-Agree - The topics or issues are critical to the field.
2-Disagree - The research questions and/or direction of inquiry are clear and compelling.

Significance Comments:
This proposal is centrally about STEM education a perennial topic of interest and inquiry. The focus on astronomy and immersive technologies is a novel space to explore in the well-trodden landscape of STEM and technology. That being said, the proposal does not seem to pose specific research questions beyond the implicit questions of can we create “scientifically accurate, immersive, engaging, visually stunning, and modular 3-D astronomical models” and then what happens if/when we do. That lack of specific questions tied to either astronomy content (e.g., is there a specific topic particularly well-suited to immersive technologies?) or technology (e.g., can a specific technology be leveraged to teach astronomy?) is a weakness of the proposal.

Connection to Research and Theory

3-Agree - Relevant research literature is used effectively in the proposal to justify the proposed work.
2-Disagree - Theory is used to explain how the proposed research will contribute to or challenge current understandings of education.

Connection to Research and Theory Comments:
The proposal does a nice job of situating itself within a series of relevant literatures, including prior work on technology in astronomy education and learning theories, including cognitive load theory and social semiotics. That being said, the proposal could be further strengthened by more directly connecting these frameworks and prior findings to the proposed work. It was not immediately clear how prior work informed what the researchers will and won’t do as part of the project. Additionally, a more detailed review of closely related work on successful examples of using immersive technology in STEM fields could be useful to help the reader understand the specifics of design directions that will be pursued. The mentioning of Phet models is useful but more detail would be helpful.

Research Design

3-Agree - Context or research sites, as well as potential study participants including access and sampling approaches (when appropriate), are sufficiently well-described.
2-Disagree - Sources of data and/or collection plans are clearly identified and well justified.
2-Disagree - Analytic methods are clearly stated and it is evident how the data will be used to answer the proposed research questions and/or support the direction of inquiry.

Design Comments:

Overall, the research design seems appropriate/adequate in some places but lacking sufficient detail in others. The most glaring area where more detail is needed is on the proposed design(s) themselves, I have little sense of what is going to be designed beyond immersive models (are they 3D?, VR?, AR? All 3?) and how learners will engage with them (homework assignments? Used in lecture? Explored in Labs? Open-ended exploration? Scaffolded inquiry?). This is critical detail. Beyond that, more information about how they will fit into the courses and who the participants and instructors will be is also helpful. Also, VR headsets are mentioned but it is not clear their role in the project (and not budget is allocated for additional purchase, so I'm guessing VR/AR will not be a part of this proposal due to lack of technological infrastructure?)

Dissemination Plans:
The dissemination plan is clear and well-thought-through. I particularly appreciate the consideration of both dissemination in academic venues as well as dissemination of the materials to other astronomy educators.

Budget and Timeline Comments:
The budget and timeline seem reasonable. My one budget comment is a lack of funds for materials for the students (e.g., VR headsets) making me question the type of technology/engagement for students but that has been discussed above.

Potential of the Research Team Comments:
The PI is well positioned to carry out the research. The unfunded co-PI seems well-positioned as well, although it would be useful to know more about their education research background. The skills associated with being an educator are not exactly the same as those needed to be an education researcher, so additional information about prior educational research would be beneficial.

Recommendation Comments:
Overall, this proposal presents a well-argued case for the need for more engaging and innovative technology-mediated astronomy learning experiences. The proposal then lays out a plan for creating such learning experiences and studying their impact. However, missing from the proposal is a clear description of what the tools might be. Topics of focus are listed but the technology and design details remain unexplored. While I realize the authors might not know all the details at the time of writing, including some ideas, potential technologies, or ways such tools might be used would go a long way in clarifying exactly what the project will produce. That lack of technological detail, clearly stated research questions, or study implementation detail produce a proposal with promise but also leaves questions unanswered.