

Project Abstract: Proposal 2415032, “Supporting Student Mechanistic Reasoning Through Scaffolded Task Design and Generative AI Feedback”

As our understanding of the world becomes ever more complex, it is important that students understand how and why phenomena occur, rather than simply knowing *that* they occur. For example, understanding the mechanisms by which a large unvaccinated population is more likely to give rise to mutations in viral infections, or why substances such as polyfluorinated alkyl substances (PFAS) are so difficult to remove from drinking water, is the first step in addressing such problems. To address this need, it will become increasingly important to support students in the construction of mechanistic explanations and models to help them explain how and why things happen. Students who engage in such activities are more likely to learn more deeply and are also more likely to be able to use their knowledge in new situations. Thus, helping students engage in mechanistic reasoning can not only serve to support students as they work to connect relevant ideas, but also can provide evidence about the depth and interconnectivity of student understanding. The goal of this project is to determine how to support large numbers of students as they construct such explanations and models, particularly in those large gateway courses that often act as a barrier to STEM success. To achieve this goal, tasks will be designed that have the potential to elicit student explanations about how and why phenomena occur. However, such tasks are typically time consuming to grade or characterize, and particularly as the phenomenon becomes more complex, it becomes difficult for students to connect all the ideas needed. To provide this support a set of generative AI chatbots, that can provide various types and levels of feedback, will be designed and trained. These chatbots will be able to accurately characterize students' responses and provide feedback in a variety of ways including in the form of a Socratic dialog.

Evidence suggests constructing mechanistic explanations in the context of formative tasks, is an equitable approach to instruction in the courses that function as a gateway to STEM careers for many students. To achieve this, it is important to support students as they regularly engage with tasks designed to support, extend and connect their knowledge. A modified evidence-centered design process will be used to determine both the cognitive and epistemic resources students need to construct such explanations, and the evidence of understanding the task should elicit for a range of complex tasks. Using those design specifications, generative AI feedback systems will be designed to support students' knowledge construction and their use. The ways that student learning and perceptions of learning are impacted by these chatbots will be investigated and will be used to produce a Framework for the design and accompanying feedback systems for tasks involving complex phenomena. The findings from these studies can be used to support transformation of higher ed STEM courses by providing guidance on how to design and engineer tasks that both provide opportunities to connect and use knowledge and provide richer insights into what students know and can do.