

Connecting Agency: Linking Funds of Knowledge, Engineering Practices, and Foundational Coursework

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Abstract: We used mixed-methods to investigate how an engineering course supported students to become responsible for building connections between foundational mathematics/physics, engineering practices and knowledge, and cultural/everyday experiences. Qualitative analysis of student talk sheds light on the nature of connecting agency and its development. Analysis of survey data show significant increases in students' connecting agency.

Introduction and research purpose

In aiming to support the variety of STEM majors, foundational STEM courses typically cover too much, rendering a fragmented experience for students. We report on design-based research that aims to support students to agentively connect their backgrounds outside of college with foundational STEM knowledge and engineering practices. Broadly, we asked: How might ill-structured, sociotechnical projects, combined with scaffolding to activate students' funds of knowledge, mitigate the impacts of instructors' agency and support first-year engineering students to agentively connect their everyday and cultural experiences with their foundational STEM courses and to the work of engineers?

Theoretical framework

We define connecting agency as the capacity to agentively make connections among everyday/cultural experiences; foundational but often decontextualized math and physics concepts; and engineering practices and knowledge. We draw together theory on learner agency, funds of knowledge, and problem typology. Compared to many problems students encounter in schools, design problems are ill-structured (Jonassen, 2000), meaning there are multiple solutions that satisfy the problem and such problems must be framed in order to be solved. Designers use their framing agency to make consequential decisions about how to frame (Svihla et al., 2021) and then solve the problem. But in classrooms, instructors hold structural power that limits learner agency. Even in project-based classrooms, instructors wield their agency as they scaffold student access to ill-structured problems. However, scaffolding students to recognize the relevance of their funds of knowledge could increase student agency, including for framing ill-structured problems. Students' *funds of knowledge*—their everyday and cultural experiences—when valued and activated, form a foundation for formal learning (Moll et al., 1992). In universities, with students from many and diverse communities, it can be difficult for faculty to identify students' funds of knowledge (Kiyama & Rios-Aguilar, 2018). However, faculty can use surveys or assignments to elicit students' experiences in ways connected to course concepts (Verdín et al., 2021). In the current study, we investigate ways to support students to recognize and make meaningful connections agentively—to develop connecting agency.

Methodology

We used design-based research to investigate how variants of a design shaped students' perceptions about their connecting agency. The study was conducted in a required first-year, 1-credit chemical engineering course at a Hispanic-serving research university in the Southwestern United States ($N=39$, $n=11$ focal students). We designed two projects as instantiations of the humble theory: (1) Teams chose a community in New Mexico, investigating its energy sources and needs; (2) Students identified math/physics concepts they found irrelevant and developed activities to teach these concepts. Data included student work, a pre/post survey, field notes, and semi-structured interviews with focal students to gain insight into the connections between their developing interests in engineering, the physics or math classes they were taking, and the project. We developed a coding scheme informed by funds of knowledge (Verdín et al., 2021) and used systemic functional linguistics (Eggins, 2004).

Results and discussion

Overall, we found that by the end of the semester, students more strongly reported making connections between their funds of knowledge and mathematics or physics concepts, $t(29)=-2.5$, $p=.049$, and they reported higher responsibility for making such connections, $t(30)=-5.86$, $p<.001$).

Using the tools of systemic functional linguistics, we characterized connections students made. For example, Anson connected renewable energy with his funds of knowledge of living in New Mexico: “Because ideally they kept the focus of us on New Mexico so that ideally we’d be able to suggest something and learn about the potential implementation of renewable energy, specifically in our own communities and something that we might see in the future even.” Anson’s speech shows a mix of low and medium agency. The clause “they kept the focus of us” denotes low agency, using the roles of agent (the one who causes action to occur) and actor (performs the action) (Eggins, 2004). “They” are both agents and also the actors, while “us” is the recipient of the action, not the one causing the action. Thus, “us” has a passive role and possesses low agency. Considering personal pronouns, “they” is the subject, and “us” is the object of the preposition “of.” Typically, the subject is the actor, indicating higher agency, while the object is the receiver of the action, indicating lower agency. In this clause, “they” (as the subject) are exerting control. In contrast, “us” is acted upon, indicating that “us” has low agency. This receiving role is further emphasized by its position as the object of the preposition. The degree of agency changes in the next clause, as “we” manifests shared agency, involved in the action. The modal verb (“we’d be able”) indicates that “we” has the potential to perform the action of suggesting, but it is not definite (Eggins, 2004). Given the low agency displayed in the prior clause, the connection Anson noted between renewable energy and his community is externally prompted.

Hollie made a connection between physics and calculus concepts and her fund of knowledge of helping each other in her family: “My younger brother who’s in high school. I’ve also been taking what I’ve learned and, uh, through my research through this class, and applying it also to helping aid him in his physics and math class with like, like derivatives and then also the position functions with physics.” Her high agency is evident through her active involvement in her brother’s education, displaying initiative in taking the knowledge gained in class and transferring it to her brother’s education. This demonstrates high agency as Hollie actively made connections between different aspects of her life, utilizing resources to support others. Linguistically, the first-person pronoun “I” and the verb of material process “taking” indicate her direct engagement with her own learning experiences. This high agency is further reinforced by the verbs of material processes “applying” and “helping,” showcasing how Hollie actively used her acquired knowledge to assist her brother. Hollie’s use of technical terms related to physics and math, such as “derivatives” and “position functions” reflects her understanding of the subject matter, thereby enhancing her agency by showcasing her command over the academic content.

Our results suggest the projects supported students to recognize and leverage their funds of knowledge as they made new connections to concepts they identified as irrelevant. In the first project, students shared connections between their funds of knowledge and engineering, but not to mathematics or physics. In the second project, they shared connections between generic examples and mathematics or physics with higher agency.

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