Abstract

The Next Generation Science Standards (NGSS Lead States, 2013) ask science teachers to address both science and engineering content and processes in school curricula and assessments. STEM teacher education programs in the United States do not traditionally include any formal or informal classroom experiences to support pre-service teachers with the development of disciplinary knowledge in engineering (Katehi, Pearson, & Feder, 2009). In addition, clinical programs in which pre-service teachers engage for student teaching often take place in classrooms that do not provide examples of how to implement engineering experiences in the science classroom.

This is a preliminary evaluation of the impacts of a pre-service teacher engineering education program that integrates engineering and science into a secondary science education methods class. These engineering education learning experiences (ELEE) included a variety of activities (speaker panels, engineering laboratory tours, ‘maker space’ workshops, and model STEM or science, technology, engineering, and math lessons) for developing knowledge and practices for integrating engineering into science instruction. The goal of the ELEE program was to engage the participants in experiences that represent how engineering is a field of study for all students who are interested in creatively solving problems to meet human needs.

Methods

Our hypothesis was that involving teacher education students in different engineering education learning experiences would support these students with identifying how they could make use of engineering activities to help their students learn science.

The design of the different ELEE activities were guided by Social Cognitive Theory (Bandura, 1977) to develop pre-service students’ capabilities by integrating engineering practices into science teaching. Social Cognitive Theory relates self-efficacy, or the level of belief in oneself to take action, with social experiences that can impact one’s emotional and behavioral aspects to being able to participate in or control the action (Clark, Byrnes & Sudweeks, 2015). The ELEE activities allowed pre-service students and their mentors to participate collaboratively in “social experiences” that included structured pedagogical discussions about teaching and reflections on the integration of the science and engineering modeled in each ELEE experience.

Collected data included written reflection statements produced by the pre-service students (n=16) for each of the five model STEM lessons that occurred in a three hour seminar. Each two-page reflection was guided by the same prompts that asked students to “synthesize one or two important ideas (descriptive reflection), provide insightful (analytical) reflections about what you learned” and “be explicit about what you will and will not (evaluative reflection) apply to your future teaching.” Analysis followed a grounded theory approach (Lincoln & Guba, 1985). Characteristics of a naturalistic inquiry seeking themes in qualitative data.

References:


Results/Discussion

Preliminary findings represent several emergent themes related to the use of engineering activities for teaching science:

Theme “Problematizing the Science Content with an Answerable Question.”

Pre-service teachers noted that they “…intend to integrate answerable questions in the frame of labs” and they felt that “…each group was focused on solving a common issue—how would we survive in space…”

Theme “Addressing Real World Needs to Make Science Content Accessible, Engaging, and Useful.”

Reflection comments include how the engineering activities “…allow students to identify problems in society or their local communities that they are personally interested in…This is science in action, and science with a purpose.” And “In this 3 day teach, I realized this connection, that if students cannot see the phenomena, the concrete, it will be harder to move towards the abstract, more higher order thinking.”

Theme “Using the Collaborative Social Aspects of Engineering to Support All Students with Learning Science”

Reflection comments noted that model STEM lessons “supports effective collaboration” through — the designation of roles and responsibilities…everyone must actively participate.”

The pre-service teachers commented on how the engineering activities supported all students with learning science, noting “this type of activity, I imagine, would develop the confidence of young scientists, particularly with underrepresented students as they would enjoy small and numerous successes: assembling the light box, using tools, generating data, and applying their data to accept or reject their stated hypothesis.”

Implications

Pre-service student teacher reflections include statements that indicate that they recognize how engineering can be used to support student learning of science content and practices, and the reflections identify strategies that are representative of positive beliefs for using engineering tasks in their own classroom teaching.

The ELEE program was designed to support the pre-service students with associating positive emotional experiences with the integration of science and engineering. For example, the panel, tour, and modeled lessons were designed as “vicarious experiences,” allowing participants to observe how engineers and master science teachers support the integration of engineering and science content. The maker space workshops were designed to provide pre-service students and mentors a space to participate collaboratively in “social modeling” by engaging in pedagogical discussions about the use of effective teaching practices in the modeled engineering lessons. Peer intervention allowed pre-service students to receive positive feedback on their ideas, their concerns, and their use of teaching practices when reflecting on their learning about using engineering in the science classroom.

Exploring pedagogies that help pre-service teachers learn and apply engineering design knowledge and skills in the science classroom, while also impacting their beliefs about the importance of these practices, is important for teacher education and professional development.

Acknowledgements

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The U-M Noyce Program’s Primary Investigator is Dr. Elizabeth Moje

Conclusion

This preliminary evaluation of the impacts of a pre-service teacher engineering education program that integrates engineering and science into a secondary science education methods class. These engineering education learning experiences (ELEE) included a variety of activities (speaker panels, engineering laboratory tours, ‘maker space’ workshops, and model STEM or science, technology, engineering, and math lessons) for developing knowledge and practices for integrating engineering into science instruction. The goal of the ELEE program was to engage the participants in experiences that represent how engineering is a field of study for all students who are interested in creatively solving problems to meet human needs.

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