Focusing on the E in STEAM: Developing Engineering and Design Capacity in Preservice SBAE Teachers

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Introduction/need for innovation

Interdisciplinary learning has become increasingly important within educational settings, and school-based agricultural education (SBAE) is well positioned to incorporate STEAM (Science, Technology, Engineering, Arts, and Math). Within the [class name] at [institution], learners engaged in *Engineering and Design Week,* grounded in Kolb's experiential learning theory (Kolb, 1984). Preservice teachers had the opportunity to learn about the engineering and design process, followed by an immersive experience where they engaged in the engineering and design process through design challenges, followed by reflection, and reiteration that resulted in a shift of their understanding of engineering and design within SBAE.

This innovative idea outlines a novel approach to developing knowledge and skill surrounding the engineering and design standards within the Next Generation Science Standards (NGSS), supportive of the science and engineering components of STEAM. The need for this innovation is supported in several ways. First, it's been over a decade since the publication of the NGSS (National Research Council, 2013), yet despite this school-based agricultural education (SBAE) teachers still need support in implementing the Engineering and Design Standards (Author, 2018). Anecdotally, students within the course report not having experienced design and engineering standards as learners in secondary agriculture programs. This innovation intentionally addresses the gap by providing opportunities to engage as a learner of Engineering and Design, while building capacity to plan for NGSS aligned instruction within their future classrooms.

How it works/methodology/program phases/steps

The Engineering and Design Week included two class meetings, each three hours in length, plus additional flipped classroom-style prework (ticket in the door) expected to be completed before arriving to class. Throughout the course, learners were charged with applying their learning to a capstone unit of instructional design (a 3-5 lesson sequence) that included at least one NGSS standard. The intention of the Engineering and Design week was to build awareness of the NGSS Engineering and Design standards, as well as engage in the engineering and design process from the perspective of the learner. During the week, learners engaged in the first of two design challenges: the first, creating a laser-engraved bookmark to commemorate a key learning about engineering and design, and challenge two, which was to develop a manipulative for their capstone unit project that supported student sensemaking.

1. **Day 1 Ticket in the Door** (prior to class meeting) – Using the learning management system, students were provided an overview of the week and the foci for the two class meetings, as well as clarity on how the content connected to the summative capstone course project. In preparation for the first-class meeting, learners explored the definition and examples of realia, an Engineering and Design Process video, and the NGSS high school Engineering and Design Standards (ETS) for the NGSS.
2. **Day 1 – Engineering Challenge 1** - Learners gained clarity on the constraints and criteria for the challenge. Then, they brainstormed a design, created the design file, and engraved their prototype(s) with feedback/reflection throughout.
3. **Day 2 Ticket in the Door** – learners explored more in depth the purpose and uses of manipulatives.

4. **Day 2 Design Challenge 2** - learners brainstormed the manipulative they'd like to create and had work time to design and prototype with feedback and reflection throughout.

Results to date/implications

During the week, students noted that they gained confidence in the engineering and design cycle. They were also able to articulate in several ways that the ETS standards could be applied to their future classrooms across various content areas. All learners completed both design challenges by the end of the course. The opportunity to design the bookmark connected to the A in STEAM, as the outputs were diverse, and represented individual learner identities. With design challenge two, learners created prototypes of various formats including wooden puzzles, popsicle discussion sentence stems, chemical bonding models, and discussion dice. The implications of this project are notable. First, students at [university] are now utilizing ETS standards in their lesson planning during clinical practice where it fits, whereas previous cohorts had not. Second, several learners have noted that using the laser engraver built their self-efficacy with the tool and have stated that they plan to get one for their classrooms when they enter teaching. Third, students have a deeper understanding related to the use of manipulatives within instructional sequences and felt empowered to develop tools they needed if they were not able to find them through other sources. Additionally, institutional leaders who attended and end of course showcase, where students shared their projects and manipulatives, were complimentary about the utility of prototypes in supporting student sensemaking in secondary classrooms, as well as the capacity to support language learning.

Future plans/advice to others

We will continue to utilize the Engineering and Design week as part of the [course]. We are looking forward to being able to share samples of student work as we support future cohorts in engineering their own capstone project manipulatives.

We acknowledge that fiding time in existing curriculum to add another week of instruction could be challenging, however, we were able to do so by embedding other key concepts from the course as part of this project, including the focus of utilizing manipulatives and teaching methods that support disciplinary literacy.

We recommend that whatever the engineering and design out put you choose, make failure cheap. Meaning, choose materials that allow learners to iterate without the pressure of worrying about materials cost. With the laser engraver, bookmark blanks are $0.18 per item, and therefore, students can use several to practice prototyping without a burden to the materials' budget. We also recommend that if using the XTool, Mac and PC are required to connect directly to the equipment.

Costs/resources needed

Direct costs will vary based on the context of implementation of the engineering output. In this project, costs included the purchase of an XTool Laser Engraver ($1,500), and materials. In this project, learners opted to use wood for their designs, which ranged from a package of 50 bookmark blanks ($9) and 4" x 4" blanks ($9), and 100 pk wooden dice ($16). While XTool design software is free and works on many deceives, we found it best to cut and engrave using a Mac or PC. *Indirect costs* associated are closely linked to the time required to prepare the course materials including LMS updates, materials orders, and learning to use the design software and engraver if the output is related to this specific conception.

References

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