



Engineering Pathways for P-12 Teacher Preparation

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Engineering Pathways and Integrated STEM for P-12 Teacher Preparation

When the preparation of the next generation of STEM teachers is discussed in education circles, few think of teachers earning an engineering degree as a pathway to entering the teaching profession. Teachers prepared with an engineering degree are well equipped to help young learners “connect the STEM dots” through design, problem solving, experimentation, making, and understanding the balance between the designed and natural world in which they live. STEM learning is often abstract and STEM subjects are too often taught in isolation without reference and meaningful connections. This NSF-IUSE project broadens the STEM learning landscape by emphasizing integrated STEM (iSTEM) teacher preparation that includes integrated design across STEM subjects by not only preparing a new type of engineering trained teachers, but redesigning the traditional STEM teacher preparation model to include cross STEM discipline teacher preparation that emphasizes content border crossings and prepares teachers to work in cross functional diversity teams in schools. The project integrates new design projects in the engineering curricula for pre-service STEM teachers and a new cross-discipline STEM methods course that will serve as a model for other institutions to adopt. Versions of the content of new STEM methods course designed and implemented at one university and designed but not yet implemented at another university have been developed.

In an effort to broaden the impact of this project a summer workshop was held with a select group of invited universities. Results from that summer workshop indicate a range of approaches for new engineering pathways for pre-service teacher preparation will be required to reflect the particular culture of the universities. Potential approaches identified include:

- The use of a minor in STEM education to complement an existing engineering degree, this reflects additions to existing undergraduate engineering degrees
- Post-Baccalaureate degree programs –this minimizes impact to undergraduate engineering degrees
- Working with educational technology programs –they tend to have greater flexibility than traditional engineering degrees –allowing for shorter degree programs
- Potentially develop new STEM licensure programs –combining the pre-service preparation across the disciplines

All of these approaches build on the original concept of using engineering as a foundation for pre-service teacher preparation programs.

Preparing teachers through an engineering degree pathway and cross-training STEM teachers opens a whole new perspective to STEM teaching, learning, and research. Research conducted in this project is designed to unpack and measure two new inventive frontiers in STEM learning; 1) STEM associational fluency and 2) teaching and learning in cross-functional STEM diversity teams. STEM associational fluency in teachers is the teacher’s ability to fluidly and deeply apply STEM content and contexts while designing and delivering instruction. Scales designed and tested include the expansion and refinement of an iSTEM scale to measure STEM associational fluency in teachers. The new STEM course mentioned above was implemented at tested at one of the universities. The participants for this study included 32 students in a senior methods course at Texas A&M University, located in an urbanized area with several smaller rural

towns located within a 30-45 minute drive of the university. Of these participants, 29 were female. 20 of the students identify as White, 10 as Hispanic, and 2 as African American. All students were seniors in terms of credit hours and ranged in age from 20 to 30, with a majority of the students being 21 or 22. The department in which these participants reside offers a Bachelor of Science in Interdisciplinary Studies with certification in EC-6 or middle grades with either a math/science or Language Arts/Social Studies specialization. The participants will be certified to teach math and science in the middle grades. In addition to course-work, the students spend extensive time in the middle school classroom as part of their field-based experience.

This study utilized a posttest only design. The participants were invited to answer questions on a post-survey once the projects were completed. 27 of the 32 participants completed the survey about their experience. Questions centered around understanding the participant's experience with the project, but also included some demographic questions. Table 1 lists the questions and their respective research questions. A selection of the results organized around three research questions from the study is given below:

How did the students view this type of activity?

For many of the participants, this activity was a new experience for them. Some participants revealed that they had prior experience co-planning projects or activities with other content areas, however a majority stated that they had limited experience co-planning such intense design projects between content areas. The overall feelings about the project were positive, and the students listed several benefits of the assignment.

What problems did the students encounter during the activity?

Many of the participants focused on design implementation issues. The participants that listed design problems also shared how they were able to overcome the problems. Their responses show their ability to think through problems and generate solutions when faced with design issues.

After participating in the activity, what value do the students see in using engineering design problem projects?

Although all but one said they found value in this type of activity, the survey question "*Do you believe you will be able to use 'making' in your classroom?*" revealed that participants still had misconceptions about design thinking problems and that there were several perceived barriers to conducting such projects in the school.

The use of engineering methods and design problem thinking has shown to be beneficial to not just K-12 education students, but also to teacher education and preservice teachers as well. In summary, this project adds a new focus to the role of engineering educators in the efforts to incorporate engineering content in the P-12 education system. Many past efforts have focused on short-term training of in-service teachers, content development, and content delivery through extracurricular efforts. This new approach focuses on an innovative approach to developing future teachers. The goal is to develop P-12 teachers who are fully trained as engineers in addition to obtaining all the traditional training of a P-12 teacher. Efforts are continuing to refine new pathways along with further developing the integrated methods course in response to the issues

Table 1: Survey Questions

1. Describe your experience related to co-planning with other STEM content areas. (RQ1)
2. What problems did you encounter while you were working on this project? How did you solve these problems? (RQ 1 & 2)
3. What portions of the project did you find difficult and why? (RQ 1 & 2)
4. Do you feel you and your content area are valued in the design process? Why or why not? (RQ 2)
5. What value, if any, do you see in using design thinking in the classroom?
6. What value, if any, do you see in using 'making' in the classroom? (RQ 3)
7. Do you feel this experience provided you with an opportunity to focus on improving student-learning outcomes? Why or why not? (RQ 3)
8. Do you believe you will be able to use 'making' in the classroom? Why or why not? (RQ 3)

identified by the studied described herein.