

The Evolution of an Engineering Problem Solver

On Minnesota's Mesabi Iron Range, a new model for engineering education has been funded and began delivery in January 2010. The IRE (Iron Range Engineering) model is a project-based-learning (PBL) model in which students work with industry on design projects with a focus on producing graduates with integrated technical/professional knowledge and competencies. Students at IRE are upper-division engineering students most of whom are graduates of Minnesota's community colleges. IRE students do not take classes. 100% of their learning is done in the context of the projects.

Since the publication of Engineer 2020 (and before) there have been numerous calls for a new-look graduating engineer. With guidance from some of the most respected leaders in engineering education, the IRE model has been developed to utilize industry-based PBL, student developed learning objectives, outcome-based assessment, just-in-time interventions, self-directed learning, and emphasis on reflection to graduate engineering practitioners.

We believe the beginning of the IRE program presents a tremendous opportunity for research on how engineering learners develop. The overarching intent for this project is to investigate the extent to which students in an entirely project-based curriculum with industry-originated projects acquire knowledge and competencies that repeated national reports have stated to be especially important in the coming decade.

Using a control group design and mixed methods, we will study 11 Research Questions (see sampling below and page 9 for full list) that focus on student learning and PBL implementation:

1. How do students learn to solve complex, ill-structured industry-based problems?
2. Do students in a PBL program become better problem solvers than students matriculating in a traditional engineering program?
3. Do students in a PBL program acquire more or less disciplinary knowledge than students matriculating in a traditional engineering program?
4. Do students in a PBL program develop different professional identities than students matriculating in a traditional engineering program?
6. Do students in a PBL program develop different self-regulated learning skills than students matriculating in a traditional engineering program?
9. What environmental, staffing and financial characteristics enable the implementation of the IRE PBL program?

We will apply well-developed measurement tools, such as Perry Scale interviews, the Problem Solving Inventory, concept inventories from the CI-HUB, the Who Am I test and others to collect data with respect to the goals. A comparison group will be used.

Intellectual Merit: PBL may be the most significant pedagogical innovation in history that aligns with ABET requirements and expectations of engineers. This project would conduct rigorous research on the effects of PBL in engineering education and provide the engineering education community with high quality data on the impact of PBL. IRE provides a unique setting to study a full engineering PBL curriculum, with emergent authentic problems and to compare IRE students with a similar control group. The intellectual merit of this project comes from these unique circumstances and would provide data not previously available on the impact of a PBL program.

Broader Impacts: As has been brought to light through publications like "How People Learn", learning is promoted through context. This project advances the discovery of how well learners' develop in an authentic undergraduate PBL curriculum, and has the potential to contribute to a paradigm shift associated with the use of PBL in undergraduate STEM education. The verification of PBL for engineering education is currently an unmet need. Impact also arises from the partnerships involved in IRE; specifically, IRE represents a newly created partnership between Itasca Community College and Minnesota State University Mankato, and the proposed project partners IRE with the highly respected educational researchers from the University of Missouri. These are partnerships for the promotion of research and the development of educational practices. Results will be widely disseminated.