Project Summary

Design is an essential part of engineering activity. And yet, little research to date has rigorously studied the synthesis process. Colleges of engineering across the nation are creatively innovating new courses and curricula to improve design education. But these efforts would seem to have little prospect of achieving truly systemic reform without a fundamental understanding of the underlying synthesis process.

The research proposed is a cross-disciplinary study of the design processes used by student design teams at Montana State University. The study unit will cover senior design projects (or 'capstone' courses) in 5 engineering disciplines and 2 non-engineering disciplines. The primary purpose is to gain a deeper understanding of the human synthesis process—what makes a good designer. The investigator proposes an emerging theory of design representation to explain the very central role representation plays in designers' reasoning and creative processes. Data collection and analysis activities will test and further develop this theory. However, since it is not known how dominant the effect of representation is, the impact of representation will be assessed while controlling for other factors that impact the success of design projects.

Data collection will focus on characterizing the design process of each student team, and measuring project outcomes. Design process data will include design representations used, time/effort expended designing with these representations, design progressions, and timing of key decisions. Project attribute data will also be collected, such as team composition and diversity, motivation, technical skills, resources available, and so forth. Qualitative thematic analysis will look for patterns that distinguish "good" projects from "poor" projects. Statistical analysis will correlate design process attributes to project outcomes such as person-hours spent on the project, creativity and completeness of the final design, feasibility of final design, and whether design objectives have been met.

The proposed education activity will incorporate the research results into instructional materials and/or intervention strategies designed to enhance students' synthesis capability. These will be implemented into one or more courses, and outcomes assessed to determine the impact of the intervention and/or new materials. This will also serve as a test for the newly developed theory on the synthesis process

The implications of this project are broad-ranging since design is ubiquitous across engineering professions. A better understanding of the synthesis process will aid engineering educators across all engineering disciplines and other science/math/ technology disciplines that require synthesis skills. The research method and results can aid assessment of design projects, courses, and curricula of engineering colleges across the country. Finally, the results have potentially important implications for industrial project management and development of design tools such as computer-aided engineering.