JENNIFER L. DOCKTOR

Research Interests

My research interests include problem solving within Physics and across multiple disciplines, gender differences in course performance, the use of computer coaches and web-based environments for learning science and math, and the professional development of teachers, teaching assistants, and faculty.

Current Research

Physics problem solving rubric

My Ph.D. thesis research seeks to design an instrument to assess students' written solutions to physics problems and obtain evidence for validity and reliability. This research is interesting both for the Physics Education Research (PER) community and classroom instruction because a standard evaluation tool for problem solving does not currently exist. The instrument takes the form of a grid or *rubric*, which divides physics problem solving into five sub-skill categories. It defines performance levels for each category by a numerical "score" and a description of the criteria met to attain that score. Current categories reflect the following stages in the physics problem-solving process:

Useful Description: summarize essential problem information visually and symbolically
Physics Approach: select appropriate physics concepts and principles to use
Specific Application of Physics: apply physics to specific conditions in the problem
Mathematical Procedures: follow appropriate mathematical rules and procedures
Logical Progression: the solution is communicated clearly, focused, and logical

Phases in the research project include drafting an instrument and testing it on sample problem solutions spanning a variety of physics topics, piloting the rubric with graduate students to check score agreement and develop documentation and training materials, applying the rubric to exam paper copies collected throughout one semester of an introductory physics course, and interviewing students as they think aloud while solving problems (in progress). In addition, the final data analysis will describe common student difficulties for each problem studied and identify characteristics of physics problems that influence the problem solving process.

Gender differences in introductory physics performance

A second project I am currently involved in investigates statistical relationships between the Force Concept Inventory (FCI) physics diagnostic exam, a quantitative math exam, and introductory physics course grades for males and females. Data collected over the past 10+ years at the University of Minnesota with more than 5500 students indicates that in introductory calculus-based physics courses, women score significantly lower than men on the FCI conceptual diagnostic exam both before and after instruction. However, women outscore men on a quantitative math skills test and there are no gender differences in overall course grades. The reason for the gender gap on the FCI is not well understood but its existence has been verified and studied at other institutions including Harvard and the University of Colorado at Boulder. Ongoing research will investigate the role of students' background factors such as previous physics and math experience on their diagnostic exam and course performance.

Future Research

In the future I plan to expand my research focus on physics problem solving and assessment to collaborate with researchers in other fields and strengthen the link of such research to teaching and learning. In particular, I am interested in the ways that characteristics of problems influence or cue particular problem solving behaviors, the roles of conceptual knowledge and mathematics in problem solving within Physics and across multiple disciplines, the progression of problem solving skills within a course and into more advanced courses, and the impact of multimedia and computer technology on learning. I am also interested in exploring the absence of women and minority students in some STEM fields and the preparation of future faculty.

Problem solving in Physics

Despite its rich history, there are still many unanswered questions within problem solving research in Physics. For example:

- What characteristics of problems influence or cue particular problem solving behaviors?
- How is the mathematics used in the context of physics problem solving similar to or different from the techniques learned in a mathematics course?
- In what ways does conceptual knowledge of physics influence problem solving behaviors?
- How do problem solving skills progress throughout a single physics course and into more advanced courses? In particular, how are the problem solving strategies required for electricity and magnetism topics similar to or different from those used in mechanics?

I plan to apply the research methods and assessment tools developed during my Ph.D. research to investigate some of these questions. The problem solving rubric I developed will provide a more detailed measure of students' skills and help determine how these skills respond to changes in the type of problem, physics topic, or mathematics required to reach a solution.

Consistent with past research at the University of Minnesota, I am interested in evaluating the effectiveness of innovative approaches to teaching problem solving such as cooperative group problem solving, modeling an explicit strategy/framework, alternate problem types (i.e., context-rich or "real-world" problems), and the use of web-based coaches and other online resources for learning science and math. I am also interested in designing curriculum that is consistent with research in Physics Education and preparing educators to implement such research-based methods and materials in their classrooms.

Problem solving across multiple disciplines

An open question in cognitive psychology is whether skills learned while solving problems are entirely domain-specific or if some aspects are generalizable to multiple contexts. It is unclear how problem solving experiences from courses in one field (such as math or physics) transfer to other STEM fields such as chemistry, biology, earth science, computer science, or engineering. An even greater question is whether such skills are applied in real-world problem solving situations. I am interested in collaborating with other faculty to investigate similarities and differences in problem solving across multiple disciplines. I am also interested in using this information to create authentic problem-solving tasks to help students develop the skills required for realistic, ill-structured contexts.

Gender and minority issues in STEM fields

Despite targeted efforts there are still low numbers of women and minority students in some STEM fields. It has been my personal experience that the fraction of women is particularly low in physics and engineering, and becomes more pronounced as you advance throughout a scientific career. I am interested in exploring why some people choose to leave the sciences and what can be done to make science careers more inviting to women and minorities.

Preparation of teachers, teaching assistants, and faculty

Although K-12 teachers receive extensive preparation for their instructional role, the same is not often true for teaching assistants and future higher education faculty. I am interested in improving and evaluating the effectiveness of targeted programs such as Preparing Future Faculty or extensive mentoring and professional development programs for future teachers, both at the secondary and post-secondary levels.