

Conducting Discipline-Specific Educational Research: An Example

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Great strides are being made by cognitive psychology and the learning sciences to understand how learning occurs. At the same time the science education community is studying the learning and teaching of science in the classroom, while simultaneously attempting to bring about changes in the ways in which science is taught in our schools. Arguably these attempts at understanding and reform are most advanced in physics and chemistry, disciplines whose national societies (via their meetings and journals) have focused considerable attention on science education.

Physiology is a discipline that has more recently joined this endeavor. The American Physiological Society established a Section on the Teaching of Physiology in 1985 and established a journal, *Advances in Physiology Education*, in 1989. Shortly after this, a group of physiology teachers, educators, and educational researchers launched a program of research and faculty development. This group represents one example of how discipline-specific educational research might be implemented.

The Physiology Educational Research Consortium (PERC)

PERC is a group of 13 physiology teachers located at 12 post-secondary educational institutions across the country - from New York to California and Washington. These institutions range from community colleges to large research universities. We are all classroom physiology teachers with an interest in doing a better, more effective job of helping our students learn. We all believe that research on learning and teaching is necessary if we are to succeed in our job of helping the learner to learn. We all believe that changes in the ways we, and our colleagues, teach physiology require that we learn to change what we do in the classroom. Details about PERC and its members can be found on our web site at <http://www.physiologyeducation.org>.

PERC began as a group of consultants to an SBIR project developing physiology teaching software. Group meetings led to the recognition that we shared many interests and concerns about physiology education that went beyond the use of computers in the classroom. Grant proposals were written and our initial success in obtaining funding from NSF enabled us to successfully launch our research program. We are currently in our fourth year of funding from NSF.

How does PERC work?

Of PERC's current 13 members, three of them have functioned as investigators and 10 have served as collaborators, making available their classrooms for our research. *All of our research to date has occurred in the classroom as a routine part of the activities of the course.* In some instances student participation has been strictly voluntary, with participation, or lack of

participation, having no effect on a student's grade. In other cases, instructors have offered "extra credit" for participation. Several experiments were conducted as routine parts of the activities of the course. Approval of institutional IRBs has been sought and obtained for all of our studies.

All of the research questions that have been pursued by PERC have arisen from the experiences that PERC members have had in the classroom. Issues of interest to the entire group are identified and discussed. The investigators then write a proposal for discussion by the group. PERC members volunteer their classrooms for use in the particular experiment being considered. When funded, the project proceeds with frequent interactions between the investigators and the classroom instructors. In many cases the investigator(s) will travel to the classroom where the study is being carried out. In other studies, particularly where the research involves the administration of assessment instruments, the instructor takes responsibility for the experiment and the collection of the data. Recently we have begun to use a web site for constructing and administering assessments, greatly facilitating the running of experiments.

When data has been collected, analysis is begun by the investigators with interaction with the classroom instructors. Members of PERC generally meet twice a year, once at the annual Spring meeting of Experimental Biology (the yearly meeting of the American Physiological Society) and once late in the summer in either Seattle or Chicago. On these occasions there is intense interaction between investigators and the classroom instructors. The data that has been collected is discussed, conclusions are drawn, publications are decided on, and plans for future research are initiated.

What is PERC doing?

Our research is based on a simple model of the educational process in which we focus on the input state of the students (what they know when they begin some educational experience - whether it be the course, a laboratory experiment, a lecture etc.), the desired output state of the students (what do they know and what can they do after the educational experience) and the educational "treatment" (the course, the lab exercise, the discussion section) which is designed to help students get from their input state to the desired output state.

Thus, we have studied the knowledge that physiology faculty believe is prerequisite to success in their course and whether students actually possess that defined knowledge. As part of determining the input state of students in our courses, we have surveyed large numbers of students to determine the misconceptions (alternative conceptions, preconceptions, conceptual difficulties) that are present in three different areas of physiology.

We have studied the use of conventional student laboratories to help students correct faulty mental models (misconceptions) and have found that simple changes to the laboratory protocol can have dramatic effects on the success of the lab experience.

We are presently studying the consequences of helping students to understand and apply certain general models of phenomena that occur in many different physiological systems. We are also looking at the effects of different problem solving experiences on the mental models that students develop.

In addition to our research, PERC members have been heavily involved in faculty development activities at national and international physiology meetings and on individual campuses. We have run brief, two hour workshops and three to four days workshops. Our goal has been to inform our colleagues of the growing body of knowledge about learning and to help them learn to change what they do in their classrooms.

Where is PERC going next?

We will be continuing both our educational research and our faculty development activities. Future research will explore the mental models that faculty believe are appropriate for students at different levels (introductory courses versus upper level courses), what difficulties students have in building those models, and how we can best help students to achieve the models defined by the instructors. We will be developing and testing innovative learning resources that will help students develop the models that are defined by their instructors as appropriate for their level of experience.

In the faculty development arena we will be attempting to organize faculty development programs in which week long summer “institutes” are followed by periodic activities throughout the following academic year. This kind of repeated reinforcement is known to result in more, and more sustained, change than brief exposures to new approaches to classroom.

Some recent publications from PERC include:

- Michael, J. A. (1998). Students' misconceptions about perceived physiological responses. *American Journal of Physiology*, 274, (*Advances in Physiology Education*, 19), S90-S98. (Available as a pdf file at <http://advan.physiology.org/cgi/reprint/274/6/S90.pdf>)
- Rovick, A. A., Michael, J. A. et al. (1999). How accurate are our assumptions about our students' background knowledge? *American Journal of Physiology*, 276 (*Advances in Physiology Education*, 21), S93-S101. (See <http://advan.physiology.org/cgi/reprint/276/6/S93.pdf>)
- Michael, J. A. et al. (1999). Undergraduate students' misconceptions about respiratory physiology. *American Journal of Physiology*, 277 (*Advances in Physiology Education*, 22), S127-S135. (See <http://advan.physiology.org/cgi/reprint/277/6/S127.pdf>)
- Modell, H. I., Michael, J. A. et al. (2000). Helping undergraduate repair faulty mental models in the student laboratory. *Advances in Physiology Education*, 23, 82-90. (See <http://advan.physiology.org/cgi/reprint/23/1/S82.pdf>)
- Michael, J. A. (2001). In pursuit of meaningful learning. *Advances in Physiology Education*, 25, 145-158. (See <http://advan.physiology.org/cgi/reprint/25/3/145.pdf>)
- Michael, J. A. et al. (in press). Undergraduates' understanding of cardiovascular phenomena. *Advances in Physiology Education*.
- Michael, J. A. (2002). Misconceptions - what students think they know. *Advances in Physiology Education*, 26, 5-6. (See <http://advan.physiology.org/cgi/reprint/26/1/5.pdf>)