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Author*

*Karen Magee-Sauer, an Assistant Professor in the Department of Physical Sciences, received her B.S. in Physics from the University of Virginia and her M.S. and Ph.D. in Physics from the University of Wisconsin.*

*Karen has published on the atmosphere of Halley's comet and continues her planetary research at Glassboro. She is interested in physics education as well. She has received a grant from the Learning Assessment Center to evaluate learning in the introductory physics courses, an SBR grant to involve undergraduates in her research, and a grant from the NJ Institute for Collegiate Teaching and Learning to implement "experiential learning" in the Physics I course.*

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# *Experiential and Community Learning in Science and Mathematics*



*Karen P. Magee-Sauer*

A national colloquium sponsored by the Independent Colleges Office was held on February 4 and 5, 1991, at the National Academy of Sciences, in Washington, D.C. The topic was "Project Kaleidoscope: Strengthening Undergraduate Mathematics and Science Education." Project Kaleidoscope is an organization formed to offer a plan of action for those who want to make needed reforms in natural science and mathematics curricula at the undergraduate level. In their studies, members of Project Kaleidoscope found that gloomy predictions of the state of science education on the national level were on the mark. Among other things they found evidence for:

- An alarming low level of scientific and technological literacy in the general population
- A projected critical shortage of well-trained scientists, mathematicians, and engineers
- Severe inequities in the access of minorities and women to science and mathematics fields

The project studied successful undergraduate programs in

mathematics and science. At the colloquium, members of the project outlined the principles that guide strong programs in science and mathematics in the nation's liberal arts colleges. The following list is a condensed version of "What Works":

- Learning that is experiential, investigative, hands-on and steeped in research from the very start
- Learning that is meaningful in a personal way, makes connections with other fields, and has practical applications
- Learning which takes place in a community

The overall theme of the colloquium was, "O.K., here is what we have found to be successful. Let's understand why these programs are successful and try and incorporate these methods and ideas into our own specific programs, and let's start now."

The above list of "What Works" applies to all areas of science and mathematics teaching. I went to this colloquium to help me learn about "What Works" in teaching introductory physics.

When I first came to Glassboro, I was naive. I believed that if I stated something in class, the students would not only understand the concept, but remember it; if I did an example on the board, then, of course, the students would be able to do problems themselves. To my dismay, this was not true. Some students failed physics despite their best efforts. Most students truly worked very hard in physics. So, if the students were genuinely trying, why weren't they learning? I knew I had to make some changes in the way the course was presented, as well as encourage successful study habits.

One program that I started even before going to the Project Kaleidoscope colloquium was a workshop physics program. This program was based on research on peer learning by Dr. P. Uri Treisman.<sup>1</sup> I set up weekly workshops to encourage students to work and study together. Students usually used

the workshops to work on homework assignments and study for exams. Many students formed study groups from the workshop that later met outside the workshop setting. Attendance in workshop was optional, but students who attended found that studying in a group was a more efficient, less frustrating method of studying. They didn't get hung up or stuck as often. As a result, students definitely improved their homework grades. Students who regularly attended workshops also developed a sense of "community" by working together and pooling their skills and knowledge.

The workshop environment was a small step to encourage community learning; however, I still needed to address my approach inside the classroom. Looking closer at "What Works," I realized that when I did an example in class, performed a demonstration, or explained a naturally occurring phenomenon, I was the one who was experiencing physics. The students were left out and were only observing physics. Thus, learning inside the classroom was not experiential, and it was not taking place in a community. Therefore, I knew that the traditional learning environment in my lectures needed a major overhaul. Experiential and community learning was emphasized only during physics laboratory and workshop, when students were supposed to be applying what they learned in lecture. However, since students hadn't grasped the material from lecture yet, the laboratories and workshops weren't as beneficial as they might have been.

When deciding what I should do about introducing experiential learning in the classroom, I wanted to see what other successful programs were doing. Project Kaleidoscope singled out the innovative approach developed, implemented, and tested at Dickinson College and Tufts University.<sup>2,3</sup> This approach emphasizes experiential learning. Students acquire inquiry skills based on real experience.

The two programs at Dickinson and Tufts are very similar. The program at Dickinson replaces formal lectures with direct inquiry, using microcomputer-based laboratory (MBL) tools, appropriate curricular materials, and discussion with

peers. The role of the instructor is to help create the learning environment, to lead discussions, and to engage in Socratic dialogue with students. The program at Tufts continues to have formal lecture periods, but the lab incorporates MBL tools and appropriate curricular materials.

MBL tools are inexpensive probes connected to a Macintosh computer through an interface box. With appropriate software, the computer can perform instantaneous calculations or produce graphs. The tools are used to measure velocity, position, acceleration, force, sound pressure, temperature, and other physical quantities. In class, the students learn physics by actually doing physics.

The MBL tools are ideal to use when implementing experiential learning in the classroom. For example, when studying motion (velocity, acceleration, etc.), students use their own motion to help visualize the concepts of motion. The appropriate MBL tool gives them an instantaneous graph of their position, velocity, and acceleration. Since the Macintosh is menu-driven, students who do not have any knowledge about computers can begin to use the computers immediately. Here are some other advantages of using MBL tools to enhance experiential learning:

- They eliminate the time-consuming drudgery of data collection and display
- The data plotted is in real time so students get immediate feedback
- Since it is easy to display the data, it is easy to examine the consequences of changing the experimental conditions; thus many “what if” questions can be answered during a single period
- The tools are simple to use and set up

The programs at Dickinson and Tufts have been developed over the past five years or more. During these years, administrators did assessment tests to see if their new approach was better than the traditional lecture format. They

found that there is strong evidence for significantly improved learning and retention by students who used MBL tools over those who only attended formal lectures.

Other than the obvious advantage of improved learning and retention, there are other advantages to this experiential approach:

- Students acquire transferable computer skills
- Students learn to work together through peer discussions
- Learning is no longer passive. Students are forced to get involved in the discussion

What I plan to do here at Glassboro, beginning with the Physics I courses, is to:

- Continue organized workshops
- Incorporate MBL tools, appropriate curricular materials, and other “hands on” experiences into lecture time
- Strive to include activities which are meaningful and have practical applications

It is difficult to break the routine of the traditional lecture. However, even though some people manage to complete lecture science courses successfully, many potential competent scientists are weeded out. The threat of a shortage of scientists and engineers is a real one. Our methods in teaching science need to evolve to facilitate learning for all students.

The principles of “What Works” carry across the science and mathematics curricula. I have singled out innovative programs in physics, but members of Project Kaleidoscope highlighted many successful programs in biology, chemistry, earth science, and mathematics as well. A final report from Project Kaleidoscope, which will include topics discussed at the colloquium, is scheduled to be published in the summer of 1991. If you are interested in being put on the mailing list

for information about the Project Kaleidoscope report, send your name, title, institution, address, and phone number to:

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*Notes*

<sup>1</sup> P. U. Treisman, *Study of Mathematics Performance of Black Students at the University of California Berkeley*, Diss. 1985.

<sup>2</sup> P. W. Laws, "Workshop Physics: Replacing Lectures with Real Experience," Conference on Computers in Physics Instruction, N. C. State University, 1988.

<sup>3</sup> R. Thornton, "Learning Motion Concepts Using Real-Time Microcomputer-Based Laboratory Tools," *American Journal of Physics* 58 (9), 1990.

