# *Guest Editor*
# STEM Innovations and Dissemination: Improving Teaching and Learning in Science, Technology, Engineering and Mathematics

R. Sam Larson

In 1999, the National Research Council published *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology*. This report stated that the understanding of science, technology, engineering and mathematics (STEM) by most Americans was inadequate for full participation in an increasingly technological world. The report proclaimed that we were becoming a nation divided into a technologically knowledgeable elite and a disadvantaged minority. Business leaders have also decried the United States' declining prominence in science and technology. John J. Castellani, president of the Business Roundtable, an association of corporate chief executives, says that the current situation "threatens to undermine our standard of living at home and our leadership in the world" (Walters 2005).

We see proof of these claims in our students. ACT scores in 2005 indicate that test takers are not prepared for first-year mathematics and science courses in college (Hoover 2005). And we find evidence of these claims in our classrooms. It is not uncommon for universities to report that up to 50 percent of students in introductory mathematics and sciences withdraw or fail these courses. For students who succeed in these entry level STEM courses, this is likely to be the terminal STEM course they take—with a consequent precipitous drop in the number of domestic majors in STEM disciplines.

How can we respond to this crisis? We must improve undergraduate STEM education. We know from years of research on education, both in STEM and more broadly, that student learning is enhanced when students are engaged in the process of inquiry beyond the mere acquiring of facts. Students need more than content knowledge delivered in traditional lecture methods. Students need to learn problem-solving and critical thinking skills, as well as an organized understanding of fundamental concepts and practical skills in methods of inquiry. Metropolitan campuses, private universities, large public research universities, and two-year colleges are all addressing ways to improve STEM education. The need to change how we teach may be more imperative at metropolitan and two-year institutions that enroll high numbers of students at risk for failing or withdrawing from science and mathematics courses.

The National Science Foundation's (NSF) Division of Undergraduate Education (DUE) supports faculty development of new pedagogies and models of instruction that strengthen STEM education at colleges and universities. In this issue of *Metropolitan Universities*, we profile four STEM pedagogical innovations, supported by DUE, that have proven effective in increasing student learning: JiTT, PLTL, case studies, and POGIL.

Andy Gavrin, Associate Professor of Physics and Associate Dean of Science at IUPUI, writes about Just-in-Time Teaching or JiTT. JiTT uses probing questions via the Web to help students prepare for class and to help faculty identify concepts students are grasping and those they are not. The faculty can then adjust their class period(s) to meet the learning needs of the student "just-in-time."

Pratibha Varma-Nelson, Professor of Chemistry and Chair of the Department of Chemistry, Earth Science and Physics at Northeastern Illinois University, tells us how Peer-Led Team Learning (PLTL) complements lecture-based classes. Small groups of students meet weekly to work on carefully structured problems under the guidance of a trained peer leader.

Clyde Freeman Herreid, Distinguished Teaching Professor, Academic Director of the University Honors Program, and Director and founder of the National Center for Case Study Teaching in Science, illustrates how case studies can be used to "revolutionize" teaching. Cases are stories told with an educational message. Case studies include facts, but more than that, students learn about the scientific process and see the relevance in the facts.

Richard S. Moog is Professor of Chemistry at Franklin and Marshall College and Project Coordinator for the POGIL Project. He and his co-authors have developed, implemented and tested Process-Oriented Guided Inquiry Learning (POGIL). Students in classrooms and laboratories work in small groups on specifically designed activities that follow a learning cycle paradigm.

Each of these innovations is relatively easy to use in a classroom, each focuses on engaging students in the process of inquiry, and each lends itself to STEM and other disciplinary areas. Further, each has evidence of improved learning outcomes when the innovation is used. These are proven instructional strategies—they work! Why, then, don't we find them, and other proven educational pedagogies and innovations, in more STEM classrooms?

The translation of STEM education evidence into teaching practice and the achievement of broad impact proves elusive. Certainly this is, in part, because of the challenges of generating any kind of change in an academic institution. Anyone who has worked with faculty, or has been a faculty member, can attest to the challenges of encouraging faculty to change what they do and/or how they do it. But pointing fingers at faculty is simply insufficient. The dissemination of these new pedagogies, and others, is inadequate. Dissemination of these innovations often times is the sole responsibility of the innovator—we find no evidence of complex dissemination strategies that includes innovators, associations, universities, chairs, and colleagues all of whom can be critical to the dissemination of an innovation.

Each innovator discusses efforts to disseminate their pedagogical innovations. Three other articles examine other approaches to dissemination that may be more effective.

Mark R. Connolly, researcher and evaluator, and Susan B. Millar, senior scientist, both with the Wisconsin Center for Education Research, describe the role that workshops play in disseminating STEM instructional strategies. They point out that we know little about the effectiveness of this dissemination strategy and suggest ways to measure and increase impact of workshops on faculty teaching behaviors.

Kimo AhYun, Associate Professor of Communication Studies and Center Associate at the Center for Teaching and Learning at CSU-Sacramento, along with his colleagues, touch upon an underutilized means of disseminating STEM instructional strategies—Centers for Teaching and Learning. CTLs, individually and collectively, need to become more active and engaged in STEM education and the authors suggest ways to do that.

R. Sam Larson, Assistant Professor in the School of Communication Studies at Ohio University, and Gary Meyer, Associate Dean and Associate Professor in the Diederich College of Communication at Marquette University, suggest tapping into a largely ignored means of dissemination—opinion leaders. Opinion leaders are individuals who informally influence our behaviors and attitudes. Early evidence indicates that faculty are influenced by opinion leaders in their departments.

The intent of this issue is to illustrate that we can address the national crisis in STEM education through wider use of instructional strategies proven to be efficacious. These strategies or innovations are not costly and, we believe, are easy to adopt and implement. The barrier to large-scale impact is in our underspecified dissemination strategies. This connection is made by James W. Dearing, Senior Scientist at Kaiser Permanente, in his concluding remarks, "Joining Evidence-based Innovations with Evidence-based Dissemination."

I hope that this journal issue devoted to STEM innovations and dissemination becomes a launching pad for a much larger and multi-disciplinary conversation about how we meet the educational challenges explicated by the National Research Council; challenges observed daily on our campuses.

## References

Hoover, E. 2005. ACT Scores Hold Steady in 2005. *Chronicle of Higher Education* A48 (September 2).

National Research Council. 1999. *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology.* Washington, DC: National Academy Press.

Walters, A. K. 2005. Business Groups Warn of Gap in Science and Math. *Chronicle of Higher Education* A21 (October 5).

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