Facilitating Change in Undergraduate STEM: An Invitational Symposium Integrating Multiple Perspectives

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Improving Technology Expertise in Mathematics Instructors

Maria H. Andersen, Muskegon Community College

Many professional development experiences for math instructors seek to encourage the use of a specific technique or the use of a specific piece of software or hardware. Such experiences make an implicit assumption that the instructors already have threshold technology skills that make them likely adopters of new technology skills. Personal experience, however, kept showing me that the average college math instructor does not possess these threshold technology skills. As software has been updated, and new programs have been installed on office computers, instructors have not kept up-to-date. College faculty development programs tend to focus on broad skills, and STEM subjects, in particular, present their own technological software difficulties. Few faculty development departments have the STEM-specific staffers that can do an adequate job of teaching math- and science-specific software and technology to instructors in these fields.

In May 2008, Muskegon Community College hosted a week-long math and technology workshop to "update" the technological skills of community college math instructors. Twenty-four participant volunteers came to Muskegon, Michigan and surrendered themselves to learn a wide variety of technology skills that would help them in both their administrative and instructional lives. Participants learned some math-specific skills, like how to use math equation editors, browse digital libraries, and use video screen capture technology. In addition to these skills, the workshop focused on other vital threshold skills for today's tech savvy instructor: creating a web page, managing internet bookmarks, understanding Internet plug-ins, backing up files, managing email, and using advanced features of commonly used software (like editing tables or using Track Changes).

Assessment results from the workshop participants were telling, but not surprising. Many participants were repeatedly confronted with the fact that there were many useful features of often-used software that they did not know existed. Participants reported useful applications to their professional lives from all the skills they were taught, not just the math-specific skills. The problem with lack of software expertise seems to be twofold: first, many instructors are not even aware that the software exists, and second, instructors overestimate knowledge of software that they use. This poster will present the assessment data from the workshop, as well as plans for continuous support through an online interactive platform.

Identifying Connections within the Literature on STEM Instructional Change Using a Historiographic Approach

Andrea Beach and Charles Henderson, Western Michigan University

The authors have completed a preliminary content analysis of the research literature related to promoting change in STEM instructional practices in higher education that has been presented at other times during the symposium. This poster represents an additional analysis using the same set of over 300 journal articles compiled from an interdisciplinary literature search. The citation analysis was accomplished through the use of HistCite®, a powerful software package that uses a historiographic algorithm to allow researchers to trace the connections among the cited references of published journal articles and map the timelines of the development of the literature in a given field. The software was designed to integrate with the Web of Science, an extensive index of science and education journals. Approximately half of the journal articles we identified as addressing instructional change were indexed in the Web of Science, so their records, along with all of their cited references, were seamlessly uploaded into the HistCite database. The other half, and the books determined to be relevant, were hand entered into the database. We offer this poster to elicit feedback on the usefulness of this kind of analytic approach to literature review.

SCALE-UP: Student Centered Activities for Large Enrollment Undergraduate Programs

Robert Beichner, North Carolina State University

How do you keep a classroom of 100 undergraduates actively learning? Can students practice communication and teamwork skills in a large class? How do you boost the performance of underrepresented groups? The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project has addressed these concerns. We promote active learning in a redesigned classroom for 100 students or more. Class time is spent primarily on "tangibles" and "ponderables"—hands-on activities, simulations, and interesting questions. Nine students sit in three teams at round tables. Instructors circulate and engage in Socratic dialogues. The setting looks like a banquet hall, with lively interactions nearly all the time. Hundreds of hours of classroom video and audio recordings, transcripts of numerous interviews and focus groups, data from conceptual learning assessments (using widely-recognized instruments in a pretest/posttest protocol), and collected portfolios of student work are part of our rigorous assessment effort comparing 16,000+ students. Our findings can be summarized as the following: (1) ability to solve problems is improved, (2) conceptual understanding is increased, (3) attitudes are improved, (4) failure rates are drastically reduced, especially for women and minorities, (5) performance in later courses is enhanced.

Experiences Developing A New Physics Text

Bruce B. Birkett, Author, *Learning Physics*

Since 1999 Andy Elby and I have been working on *Learning Physics*—a two-volume, "reform-minded" introductory, calculus-based Physics text. Currently, the publication date is set by John Wiley & Sons for Fall 2009. Key features of the text include: (1) a generally constructivist approach (to the degree allowed in a textbook), using PER results to introduce and explore each topic; (2) then incrementally developing quantitative problem-solving approaches based on each chapter's few, core ideas; (3) paying attention to students' developing epistemologies all along the way. Our basic aim: to develop a text that supports (some) instructors' active-learning approach, rather than fighting against it as most texts do. (The standard approach: start with an abstract definition, then derive many formulas with inadequate discussion of the physical meaning, and finally present "sample problems" that are often two-line plug-ins.) Our dilemma: how to write a book that's aligned (enough) with our core beliefs about helping students learn well, and that's different enough to warrant the time and effort involved—while not making it so radically different that no Physics department will consider using it. I'll have sample chapters, reviewer comments, and 9 years worth of experiences to talk with you about.

From Research to Practice and Back Again: A Model for Change

Jim Borgford-Parnell, Center for Engineering Learning and Teaching, University of Washington

From its inception in 1998, the Center for Engineering Learning and Teaching (CELT) at the University of Washington focused on two synergistic activities: research on engineering education and improving engineering teaching through instructional development. This dual-role change model is based on an awareness that the dynamic profession of engineering is best served by effective teaching of engineering students. A solid engineering education research base is needed to inform educators about how their students learn, and that this research should drive and support effective teaching. Similarly, a broad understanding of what takes place in engineering classrooms is important for pinpointing important areas for research. CELT researchers and instructional consultants are deepening the scholarship and facilitating effective teaching. This model has proven successful in the UW College of Engineering and impacts engineering education at national and global levels.

Are Engineering Departments Adopting Engineering Education Innovations?: A National Survey to Assess Contributing Factors

Maura Borrego, Virginia Tech and Jeffrey Froyd, Texas A&M University

A survey is proposed to understand and ultimately accelerate adoption of proven engineering education innovations. We will survey 1,727 department heads, 271 academic deans, and 28 professional society leaders to test 14 hypotheses related to 8 engineering education innovations. Diffusion of Innovations theory, which emphasizes stages of the adoption process and the importance of social networks, will guide this research. Project outcomes include: (1) assessment of prior efforts at diffusing engineering education innovations, (2) deeper understanding of dissemination mechanisms leading to specific recommendations, and (3) increased awareness of eight established engineering education innovations through the survey process itself. Over the past 15 years, tremendous effort and funding have been invested in improving engineering education, producing innovations such as the eight to be investigated in this project: 1. Engineering Diversity Programs; 2. Summer Bridge Programs; 3. Learning Communities and Integrated Curricula; 4. Design Projects in First-year Engineering Courses; 5. Artifact Dissection; 6. Student-active Pedagogies; 7. Curriculum-based Engineering Service-learning Projects; 8. Interdisciplinary Capstone Design Projects

Among the 14 hypotheses to be tested are: H2: At each institution, no more than five of the studied innovations are currently adopted (partly due to competition for personnel and financial resources); H4: Innovations requiring coordination across academic units (e.g., departments) are adopted by fewer institutions than innovations contained within a single unit; H5: Leaders who have already heard of an innovation desire different information (to aid in an adoption decision) than leaders who have not ; H14: Innovations adopted by one department at one institution are more likely to be adopted by the same department at other institutions. In a time of tightening economic constraints on government spending, this research may ultimately influence funding programs for engineering education research and curriculum innovation projects.

The Experience of Faculty Development: Patterns of Variation and Change in Conceptions of Teaching

Susanna Calkins, Searle Center for Teaching Excellence, Northwestern University

As research demands continue to weigh heavily on junior and non-tenured faculty, the need to maintain and develop sound teaching is crucial. Yet, few studies have systematically explored how a sustained faculty development program can impact the way that faculty experience or conceive of teaching. In this study, we examine how a year-long faculty development program impacts the conceptions of teaching held by early career faculty. We interviewed 22 tenure-track faculty participants, pre-and post-program, categorizing their conceptions of teaching from the transcripts. The analysis drew on conceptual frameworks of faculty conceptions of teaching derived from phenomenographic literature. The current study identifies and explores a range of patterns of experience that emerged over the course of the program, and discusses the broader implications of these patterns for understanding faculty conceptual change.

The Science and Mathematics Teacher Imperative

Lawrence B. Coleman, NASULGC and University of California, Davis

NASULGC, A Public University Association, in collaboration with its 218 members and other organizations, has launched the Science and Mathematics Teacher Imperative (SMTI) to significantly increase the number and diversity of high quality science and mathematics teachers prepared and inducted into teaching.

Working with a distinguished Commission, the SMTI team has consulted extensively, surveyed the provosts of NASULGC institutions, and began promising collaborations with other education, business, and science societies. With this strong base, the initiative plans a multi-prong approach: 1) Galvanize higher education leadership to make STEM teacher preparation a higher priority among peers; 2) Determine how to assess the need for secondary science and math teachers, recognizing that supply and demand differs from state to state; 3) Facilitate state fiscal and policy support and increased cooperation between state policymakers and education leaders; 4) Develop the means for institutions to learn from one another’s approaches -- an analytical framework which incorporates key components of the most promising practices in science-math teacher recruitment, preparation, mentoring and induction, partnership, and teacher development across universities; and 5) Team up with selected national and regional university, science and education groups.

We recognize that highly effective and stimulating undergraduate math and science instruction are prerequisites for preparing future science and math teachers, as suggested in the 4th and 5th elements of our approach. We are keenly interested in finding connections for our Teacher Imperative with those advancing undergraduate science and math education.

Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics

Melissa H. Dancy and Charles Henderson, Western Michigan University

Many proven research-based instructional strategies have been developed for introductory college-level physics. Significant efforts to disseminate these strategies have focused on convincing individual instructors to give up their traditional practices in favor of particular research-based practices. Yet evidence suggests that the findings of educational research are, at best, only marginally incorporated into typical introductory physics courses. In this poster we present partial results of an interview study designed to generate new ideas about why proven strategies are slow to integrate in mainstream instruction. Specifically we describe the results of open-ended interviews with five physics instructors who represent likely users of educational research. We found that these instructors have conceptions about teaching and learning that are more compatible with educational research than with their self-described instructional practices. Instructors often blamed this discrepancy on situational factors that favor traditional instruction. A theoretical model is introduced to explain these findings.

Practice and Perception: A Qualitative Study Exploring the Effects of a Professional Development Workshop for College Astronomy Faculty

Erin Dokter, University of Arizona

While faculty development resources abound, STEM-specific faculty development efforts are quite limited. The purpose of this qualitative study was to explore and describe the influence of one such effort, a 2-day learner-centered professional development workshop for two- and four-year college astronomy faculty. In particular, faculty conceptions of teaching and teaching practice, the conceptions of their students, as well as the teaching conceptions of the faculty developers were examined. Data sources include open-ended, pre- and post-workshop questionnaires from over 200 astronomy faculty, teaching observations and interviews with five selected faculty, interviews with the three faculty developers, as well as Likert and open-ended surveys from over 300 introductory astronomy students. Results document the individual goals of faculty as they participated in the workshop, the complexity of their teaching conceptions and practices, the range of student interpretations of the teaching that goes on in their classrooms, as well as documenting a change in teaching beliefs of the faculty developers from year to year. This study reveals that a common faculty development workshop experience has many and varied outcomes that are highly individualized to the faculty who participate, that one success of this particular faculty development program was its discipline-specificity, and that student reactions to the enacted workshop teaching techniques were also highly varied.

Action Research, Student Learning, and Change: Reform in Undergraduate STEM Teaching

Julie Gess-Newsome, Northern Arizona University

This study describes a professional development project where undergraduate STEM faculty in departmental teams used an action research model to hypothesize root causes of student achievement problems, select and implement course interventions, and collect data to assess intervention impacts. Data was collected over the two years of the Faculty Improving Student Achievement Success (FISAS) project with follow-up data collected 18 months after project conclusion. Study results include faculty learning and course change, impacts on student learning, and institutional change. Overall, course interventions resulted in significant improvements in student learning and/or attitudes. Critical classroom interventions included using mechanisms to increase student attendance and interaction with the content, and to implement early warning and intervention strategies that can assist students in recognizing and correcting unproductive patterns of academic behavior. Sustained changes and improved student achievement were found in those departments with low faculty turn over.

UBC and CU Science Education Initiatives: Models for achieving sustainable change in university science education

Sarah L. Gilbert, Katherine K. Perkins, and Carl E. Wieman, University of British Columbia and University of Colorado, Boulder

The Carl Wieman Science Education Initiative (SEI) at University of British Columbia and the sister SEI program at University of Colorado have as their goal the achievement of sustainable institutional change towards effective, evidence-based science education. These programs fund departments to take a four-step, scientific approach to teaching: 1) Establish what students should learn; 2) Scientifically measure what students are actually learning; 3) Use instructional approaches guided by research on learning and measures of student learning; 4) Disseminate and adopt what works. While most efforts in institutional change operate only in one quadrant on Henderson et al's 'Models of Change' diagram, the SEI programs are cross-cutting. The program simultaneously works on change in structure (by initiating proposals from, and providing funding at, the department level) and change in individuals (through department-based Science Education Specialists serving as resources and change-partners for individual instructors). In addition, the program prescribes that the outcome should include the 4 basic elements (above), but the approach taken and enactment of those 4 elements are emergent and driven by the faculty. In this poster, we discuss the design of the SEI change model within this framework. With 10 departments participating across two universities, we effectively have 10 experiments in change. We will discuss various structural and model aspects that seem to facilitate change and those that act as barriers to change.

What Roles Should Students Play in Changing STEM Education?

Jack G. Hehn, Director of Education, American Institute of Physics

This poster will describe two lines of work and try to stimulate discussion of how they are related. Michael Neuscatz and I coauthored an article in *Physics Today*, February 2006, "Physics for All? A Million and Counting!" We reviewed a wide spectrum of the education of physics students over the last two decades, and we discussed the complexity of reform of the STEM educational enterprise. This poster will couple some of that work with evidence from the "Spin UP" report (AAPT, 2003) and journals from the SPS Intern Program (http://www.spsnational.org/programs/internships/2007/index.htm) to opine that undergraduate student perceptions about the environment describing their undergraduate physics program of study have profound influences on their scholastic performance, their attitudes toward physics and STEM, and their career choices.

Science faculty and educational researchers: Divergent expectations as barriers to instructional change

Charles Henderson, Western Michigan University and Melissa H. Dancy

Science education research practitioners have engaged in substantial curriculum development and dissemination work in recent years. Yet, it appears that this work has had minimal influence on the fundamental teaching practices of the typical science instructor. To better understand this situation, interviews were conducted with five physics instructors who were considered to be likely users of science education research. All reported making changes in their instructional practices and all were influenced, to some extent, by educational research. Yet, none made full use of educational research and most had complaints about their interactions with educational researchers. In this poster we describe how these instructors used educational research in making instructional decisions and identify divergent expectations about how researchers and faculty can work together to improve student learning. Although different instructors emphasized different aspects of this discrepancy between expectations, we believe that they are all related to a single underlying issue: science education researchers typically seek to disseminate curricular innovations and have faculty adopt them with minimal changes, while faculty expect researchers to work with them to incorporate research-based knowledge and materials into their unique instructional situations.

How Situated Mental Models Influence Faculty's Response to Educational Reform

Matthew Tadashi Hora, Wisconsin Center for Education Research

The dominant culture of teaching and learning among STEM faculty is sometimes cited as a reason for the ineffectiveness of STEM education reform efforts. Yet the concept of organizational culture is too often used with imprecision, lacking, for example, attention to within-group variability, cultural evolution, and relationships among cultural knowledge or beliefs and contextual factors. This study draws on cognitive anthropology by positing that individual faculty draw upon underlying knowledge and belief structures (i.e., schema) from a variety of sources to construct domain-specific mental models to interpret incoming information. The goals of this study are to identify: (1) the composition of faculty mental models salient to STEM education, with specific attention to the schema linked to or exhibited by social groups (i.e., cultural schema), (2) how these mental models are situated within local organizational contexts, and (3) the relationship between the situated mental models and faculty responses to reform efforts. This study is based on an evaluation of an NSF-funded System-wide Change for All Learners and Educators (SCALE) project, consisting of 3 qualitative case studies of Institutions of Higher Education (IHE). The data for these case studies include 121 semi-structured interviews with 96 individuals, official university and SCALE documents, and observations of SCALE meetings. Analytic procedures include inductive analysis of interview transcripts using a structured coding paradigm, the identification of mental models using a variation of the narrative analysis technique of Quinn (2005), and data triangulation and member-checking. Findings include several mental models and their cultural schema for STEM instruction, inter-disciplinary collaboration, and STEM education reforms underway at each site, how they are linked to local contextual factors in the 3 sites, and how they interacted with the SCALE intervention. Conclusions are that reform leaders at the SCALE IHEs who paid close attention to the pervasive mental models operative at each location, and the unique contextual factors in which they were embedded, had greater success in engaging STEM faculty in reform efforts and in achieving their project's goals. Reform leaders and policy-makers should pay particular attention to the cultural schema for disciplinary legitimacy and credibility, and to how these schema relate to individual faculty's social and professional status, as these factors strongly affect how faculty respond to reform efforts. Limitations to this study include a small sample size, the lack of a longitudinal cohort, and rival explanations including non-cultural or non-SCALE factors that led to observed changes.

Engineering Education for the Global Environment (EEGE)

William E. Kelly, American Society for Engineering Education

The American Society for Engineering Education (ASEE) began as the Society for the Promotion of Engineering Education in 1893 and published a series of transformational reports on Engineering Education over the course of the 20th Century. Recognizing the many facets of globalization that are already driving engineering in new directions in the 21st Century, the ASEE, with the support of the National Science Foundation, is again at work to develop and then implement ASEE strategies, actions, and activities to support necessary change in engineering education. Some of the unique aspects of the EEGE effort are the goal of encouraging a more research-based approach to engineering education, raising the status of educational research versus traditional engineering research, and promoting engineering education practice.

Teachers teach the way they were taught: A physics graduate student's beliefs about teaching and learning

Yuhfen Lin

A substantial portion of undergraduate physics instruction is placed in the hands of graduate teaching assistants. If we want to effect institutional change, it is important to make sure graduate teaching assistants hold and can apply beliefs about learning and teaching that are aligned with the instructional reforms. I am going to present a case study about a physics graduate student, Brian, who held two very distinct beliefs about teaching and learning. In classroom learning, he believed that learning means receiving information from authority. He expected the instructor to provide and present the material clearly so that, as a student, he could attend the class passively. From his undergraduate research experience, Brian learned to do research under a well-structured apprenticeship model. From his experience he believed that learning in research setting meant to construct meaning and understanding for himself. Brian also transferred his beliefs about learning into his teaching. In classroom setting, he taught as a teaching assistant. He applied the transmission model of learning in his teaching and focused on delivering the required material to the students. When he was teaching new students in the research lab, he applied the constructivist model of learning and focused on guiding new students through the discovery process rather than telling them what to do. Future research should examine how we can get physics graduate students to transfer their more sophisticated epistemological beliefs acquired in the research setting, into the classroom setting.

Mobilizing STEM Education for a Sustainable Future

Susan Millar, Cathy Middlecamp, and Mark Connolly, Wisconsin Center for Education Research

Our project is identifying and disseminating effective strategies to transform the organization and practice of STEM education. Despite decades of research on teaching and learning, undergraduate STEM education in the United States is not fully meeting the challenge of producing the next generation of citizens, including scientists, who are both motivated and prepared to address the urgent problems that we now face on our planet. In 2009, our National Science Foundation-funded project will convene two groups of national experts and leaders carefully selected for their diverse knowledge and experience. The first group of critical advisors will re-envision the theories of change that shape strategies for education policy and action in institutions of higher education. The second group of critical advisors will meet later in the year to review and refine the theories of change formulated by the first group and then use the resulting theories to develop strategies that will enable institutions of higher education to meet their responsibilities to contribute solutions to current global crises through more effective STEM education. We will develop and disseminate a document that promotes these strategies to national leaders who are positioned to implement them.

Teaching, Learning and Thinking in Fractal Patterns

Edward Nuhfer, California State University at Channel Islands

This conference presumes that there are several core communities working on promoting change in undergraduate instructional practices. One community I represent is a group of faculty and faculty developers who have been working since 1993 on developing better instruction through a week-long development retreat called "Boot Camp for Profs®." Benefits of this camp have spread to other communities too.

The operating philosophy of Camp evolved from intensive training workshops, through a more coherent teaching system for individuals, and finally into a model that uses awareness of fractal properties of neural networks in the brain to aid development of successful college instructors. (See http://profcamp.tripod.com/bootcamp08.htm.) Emphases include (1) understanding the process of improving education by reflecting on the educational process through different scales, (2) recognizing paramount importance of the affective domain on successful learning and teaching, (3) realizing that assessment and evaluation are attempts to measure fractal systems, (4) recognizing that students learn better when they understand the process of brain development and what is happening to them as they learn, and (5) developing and maintaining sophisticated teaching philosophies as blueprints for action. Employment of knowledge surveys, learning documents, student management teams, and learning design exercises, which incorporate both individual reflection time and cooperative interactive engagements, further aid success for students and instructors.

Department-based Science Education Specialists as agents of change in university education

Katherine K. Perkins, Sarah L. Gilbert, and Carl E. Wieman, University of Colorado, Boulder and University of British Columbia

The Carl Wieman Science Education Initiative (SEI) at University of British Columbia and the sister SEI program at University of Colorado have as their goal to achieve sustainable, institutional change towards effective, evidence-based science education. One of the central elements of the SEIs is using Science Education Specialists as agents of change within the department. Most participating departments have used their SEI funds to hire one or more Science Education Specialists – typically individuals with a recent PhD in the discipline and a background or strong interest in education. Within the department, the Science Education Specialists serve 5 key roles to support the change process: 1) facilitate faculty communication and consensus building on a variety of topics – learning goals, assessment measures, curriculum design; 2) collect, distill, and communicate data to support and guide faculty efforts, e.g. interviews or observations to probe student thinking about content, observations of classes, surveys of pre-post measures of learning, etc; 3) serve as a local resource for the faculty on the education research literature or on new education practices; and 4) develop curricular materials and teaching approaches in collaboration with faculty, and 5) facilitate sustainability by archiving and disseminating curricular materials and supporting information. In this poster, we elaborate on these roles and present example evidence of these efforts resulting in faculty and departmental change. In addition, we will discuss specific structures and relationships (e.g. with faculty and with the department) that support and hinder Science Education Specialists' efforts to facilitate change.

Integration Across the STEM Curriculum: STEM curriculum reform at the University of Maryland College Park

Joelle Presson, College of Chemical and Life Sciences

Calls for STEM education reform have been active for several decades. Many of these calls have focused on pedagogical methods for active learning, which enhance student comprehension and retention of concepts. An equally compelling theme is the call to integrate education across the STEM disciplines, which allows students to grasp that knowledge in STEM disciplines, is complementary, and is not isolated or independent. At UMCP both approaches – active learning and interdisciplinary integration – are increasingly prevalent. This poster will focus on our efforts in STEM integration across disciplines, with a special focus on the Life Sciences and General Education. Student success in the study of life sciences requires a deep appreciation of the fundamentals in chemistry, physics, and math. This approach reflects the integration that is taking place in STEM research areas, and brings the modern research perspective to the classroom. In the realm of general education, a deep appreciation of STEM can nurtured by a focus on interdisciplinary and cutting-edge topics that also are problem areas for society at large. In contrast, the a typical biology or general education curriculum offers students unrelated courses in biology, chemistry, physics, and math, with the assumption students will bring that knowledge together – on their own. Several curriculum initiatives at UMCP address this traditional "silo" approach to STEM education. Individually each of these initiatives pushes the study of STEM at UMCP into a cutting edge arena. Collectively they place STEM education at UMCP at the forefront of national innovation. Our efforts in this area are driven by an appreciation of the BIO2010 report, and catalyzed by funding from HHMI and NSF. The progress made at UMCP arises from a common, mutually reinforcing vision on the part of the faculty and administration concerning the central role of innovative STEM education reform at a Research I University. Some of the major initiatives in STEM reform at UMCP that will be described in the poster are: 1) BSCI207 Principles of Biology III Organismal Diversity; 2) Non-traditional 1, 2, 1 Chemistry sequence; 3) MATHBENCH Math modules for Biology courses; 4) MATH/BSCI130 – 131 Calculus for life sciences; 5) MARQUEE integrative science courses for non-majors; 6) Integrative Physics for Biologists; 7) Transfer student success in STEM.

Preparing the Future Professoriate: A Methods Course for College Science Teaching

Renee' S. Schwartz, Western Michigan University

How do we prepare the future science professoriate to teach effectively? Science content knowledge and skills may be necessary, but they alone are insufficient. Emerging from the literature on teacher education, professional development, and reform in higher education, the Mallinson Institute for Science Education at Western Michigan Univeriesty has developed a course geared toward preparing students to effectively teach in the post-secondary setting. Teaching and Learning in the College Science Classroom is a methods course, modeled after those required for preservice K-12 teachers, where the focus is on building science pedagogical knowledge and skills. The course targets graduate students from the science disciplines and from science education who will seek positions in academia with responsibilities in undergraduate science instruction. The course develops reflective practices through study of contemporary teaching and learning theory, concepts of nature of science and scientific inquiry, course and lesson development, and instructional and assessment strategies that promote active learning. This is a practical application course where students practice designing, implementing, evaluating, and reflecting upon science instruction to promote higher order and critical thinking skills. Student-produced artifacts include teaching philosophy, course syllabus, instructional plans and rationale, teaching videos, and reflections on and about practice.

Fostering Creativity in the Math-Science Classroom: An Overview

Sheila Tobias

In 1990, Sheila Tobias originated the notion that there are "tiers" of students in introductory college-level science courses, which the traditional curriculum and pedagogical methods do not reach. The most "famous" of these is her "second tier," highly intellectual (usually verbal) learners whom we lose; but there are also the utilitarians, so-called, the underprepared (not a surprise) and the alienated who, together, constitute apparent non-achievers. She also reviewed reform efforts in a second book, how exams not just discourage but alienate students in a third, and the value (in terms of attracting new and different students to science) of promoting non-research career options, in a fourth. Since 2003, she has turned her attention to a need as pressing as science competency, namely fostering creativity both in classroom activities and exams as a precondition for the continued innovation that will keep the nation's economy going strong. Her contributions to our discussion will embrace her work in its entire.

Case Studies and Institutional Analysis of the implementation of a pedagogical reform in introductory physics

Chandra Turpen and Noah Finkelstein, University of Colorado, Boulder

We examine how the University of Colorado has created a sustained use of a research-based curriculum in two courses simultaneously, despite significant increased cost, and time commitment from faculty. The adoption of the research-based University of Washington Tutorials in Introductory Physics curriculum required significant pedagogical shifts such as: shift in content emphasis from computation to conceptual understanding, shift in the role of student interactions from individual work to group work, shift in student activity from watching, listening, transcribing to actively discussing, reasoning, and problem solving and shift in student-educator relationship from educator as a source of answers to educator as a source of guiding and focusing questions. Following the initial curricular implementations by physics education research professors, we describe both successful and unsuccessful hand-offs of the curriculum to professors from traditional physics research disciplines. Through faculty interviews, we capture a shift in how professors talk about this curriculum from being a choice that is made by individual professors teaching the course to professors stating that this is ‘just how we do things here’ implying that the use of the Tutorial curriculum had organically become a departmental norm. In addition to analyses of departmental or cultural change, we investigate shifts in individual physics professors’ views about teaching and learning physics before and after they implement the tutorial curriculum. We find that teaching with the Tutorials curriculum can result in shifts in professors’ views about teaching and learning physics, although this does not always happen. We describe characteristics of the professor's participation in implementing this curriculum and professor's background in order to make sense of when we do and do not see shifts.

Facilitating Change in Undergraduate STEM: An Eclectic Collection of Annotated Resources

Maryellen Weimer

Several barriers make the dissemination of resources on teaching and learning an especially challenging endeavor. First, there are no norms expecting college teachers to grow and develop as pedagogues the way they are expected to grow and develop as disciplinary scholars. As a consequence most college faculty read very little pedagogical literature. Instead they rely on experience—their own and that of colleagues. Most are not trained to teach and so their experiential understandings of teaching and learning can contain large, small and in between amounts of accurate knowledge and misinformation.

Given the absence of norms expecting growth, the lack of training and the reliance on experiential learning, what kind of resources might make teachers want to change, point out what needs to change and offer strategies with the potential to improve student learning? This collection of resources includes examples that illustrate one answer to the question.

Curriculum Reform in Support of Student Learning and Development

Terry Wildman, Virginia Tech

Two curriculum projects at Virginia Tech illustrate both the challenges and rewards of significantly changing the practice of teaching and learning for faculty members and students. One project is situated within the curriculum for liberal education and engages cohorts of students in an integrated four semester course series organized around a global theme titled *Living in the 21st Century*, and specifically focused on the topic of Earth Sustainability. Within this curriculum the traditional STEM disciplines are treated not as separate areas of study but as part of a problems based experience in which issues related to water resources, food, energy, and health require drawing from all disciplines in a coherent way. The second project is situated within the departments of Engineering Education and Biological Systems Engineering (BSE). This project focuses largely on the redesign of the entire curriculum for BSE around the concept of a *spiral curriculum* first proposed by Jerome Bruner in the 1960s. Both projects provide the opportunity to discuss ways in which research on student learning and development can be brought into play in curriculum redesign, and they also provide a good look at the barriers one can encounter in attempting to change instructional practice in a large and traditionally structured research institution. Both projects are currently supported by NSF grants.