STEM Study Team Report to the Strategic Planning Steering Committee

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The Nature and Importance of STEM Education

There is widespread concern that the global competitiveness of the U.S. will increasingly depend on the extent to which the U.S. has a well educated supply of scientific and technical personnel; teachers who are knowledgeable about STEM (Science, Technology, Engineering, and Mathematics) disciplines, their importance, and how students learn in those disciplines; and students who are interested in pursuing, and well prepared to pursue, careers that require scientific and technical capabilities. In international comparisons of student achievement (e.g., TIMSS, PISA), U.S. students' performance in science and mathematics has not measured up to that of students in many other countries, causing concern among business leaders, politicians, and educators.

Consequently, STEM Education is currently receiving considerable attention from colleges of education and colleges focused on technology, the sciences, and engineering, as well as from funding agencies (e.g., the National Science Foundation). Further evidence of the importance of STEM Education is offered by an emerging scholarly focus on STEM Education, as evidenced by the existence since 2000 of the peer-reviewed *Journal of STEM Education*. Thus, STEM Education appears to be appropriate as one of the College of Education's priorities for the future.

STEM Education occurs at many levels and in differing forms. At the pre-K–12 level, education in STEM-related content appears in a variety of venues, including the instruction that occurs in mathematics, science, and technology education activities and courses. To date, engineering education has made little impact at the precollege level, but STEM education faculty can play a role in making connections between precollege instruction and university engineering curricula. At the collegiate level education in STEM content occurs most visibly in the STEM disciplines in colleges of science, engineering, agriculture, information sciences and technology, earth and mineral sciences, etc. However, education in STEM content (science, technology, mathematics) also occurs in colleges of education as they strengthen and build upon the STEM content preparation of prospective and practicing teachers in the context of teacher education courses and professional development initiatives. In addition, STEM Education includes the pedagogical preparation of teachers to teach STEM content as well as the preparation of adults to enter the workforce in careers in scientific and technical fields.

STEM Education Within the College of Education

College of Education STEM Education initiatives have the potential to offer impact at three quite different levels:

1. Locally (e.g., impacting the quality of STEM courses within the University);
2. Within the Commonwealth (e.g., working with school districts to improve STEM Education at the pre-K–12 level, equipping a Pennsylvania workforce that can impact economic opportunity and the vitality of communities); and
3. Nationally or internationally (e.g., influencing STEM Education policy, creating opportunities for international development or sustainability initiatives through STEM Education efforts).

Given the variety of venues and levels at which STEM Education occurs, the College of Education's role in STEM Education could include many endeavors, such as research on teaching and learning of the content of the STEM disciplines at a variety of levels, the education of high quality pre-K–12 or collegiate STEM educators, research on the nature and development of technical and scientific competence needed by adults in or entering into the workforce, STEM Education policy research, initiatives to encourage students to enter technical and scientific careers in the workforce or STEM disciplines at the collegiate level, increasing the participation of underrepresented groups in STEM Education, and many others. The challenge we face is where to focus our efforts in order to best draw on our strengths to achieve maximal impact and how to engender synergy among multiple STEM-related initiatives.

The College of Education currently has various entities focused on STEM Education, including the Waterbury Chair in Secondary Education, the Center for Science and the Schools, the Professional Personnel Development Center, and the Mid-Atlantic Center for Mathematics Teaching and Learning. We believe that future STEM Education efforts should involve strengthening the areas in which we already exhibit strength (e.g., conducting high quality STEM Education research) as well as addressing new areas that have potential for enhancing the College's contributions to and visibility in STEM Education (e.g., work with schools to address the improvement of engineering and technical education at the pre-college level).

We offer the following as a STEM Education mission for the College of Education: "*We seek to deepen and extend knowledge about the teaching, learning, and utilization of STEM-related content and about the STEM-related requirements for 21st century technical and academic workplaces*."

Goals

A primary goal in response to the preceding mission is to address the following questions: What is the nature of the mathematics and science that individuals need to succeed in 21st century technical and academic/professional workplaces? What is the nature of the mathematical, scientific, and technical knowledge that is required for

students who complete school and are employed in technical jobs (e.g., hospital radiology technician, network specialist)? How do effectively functioning adults learn what is important in STEM-related jobs and professions? What is the nature of mathematics and science teaching that can contribute to the development of such knowledge and understandings of mathematics and science? In what ways do current mathematics, science, and technology-related teaching and learning address, or fall short of addressing, those needs? How do learners learn from cases (previous problems and their solutions) and develop processes that are important to STEM fields (e.g, making and testing hypotheses, collaborative inquiry, data-driven decision making)? How can schools address engineering education within their curricula?

To address the preceding questions, it will be important to study needed changes in STEM content and changes in the ways in which the sciences, technology, engineering, and mathematics are taught in order to make STEM Education more relevant to 21st century workplace needs. Equally important are changes in how people think about the STEM fields—whether they embrace or fear scientific and technical fields, whether they choose to pursue STEM-related careers, whether the public (and teachers) adapt to or resist new technologies, and the like.

These goals and questions might be addressed by identifying "key problems" in STEM Education, problems that are "big" problems as well as ones that are amenable to study, given the resources and expertise of the College's faculty. Teams of researchers that cross departmental and college boundaries could conduct research that addresses collections of key problems in the field that are shared by faculty in the College (e.g., using inquiry as a focus and studying ways in which technology can be used to teach project-based problem solving, studying the residual from collegiate-level STEM courses, studying ways in which technology transforms how people enter the workforce) and that may be of interest to colleagues in other colleges.

Recommendations

We anticipate that the College's STEM Education initiatives will be influenced by the newly appointed Waterbury Chair, so it is imperative that strategic planning for STEM Education continue upon his arrival for the 2008-2009 academic year.

1. Identify, with input from the Waterbury Chair as appropriate, productive STEM Education research areas or "key problems" that might be productively addressed by groups of faculty members in the College, the University, and/or other universities, and seek internal and external support for that research. In such efforts, College of Education faculty should be central partners with faculty from other colleges. Research teams should organize around key problems and research questions can be identified.

2. Information gathering and dissemination: Identify and disseminate existing STEM Education initiatives in the College and identify STEM activities in other entities within the University with which connections might offer potential benefits to the College's STEM Education efforts. This should include ways of informing College of Education faculty and graduate students of ways in which existing and proposed STEM Education work could inform their teaching, research, and outreach efforts.

3. Examine, over the next five years, how to expand our reach to develop STEM educators who understand the local, national, and international nature and needs of STEM Education and are better prepared for teaching in settings involving diverse learners. STEM-focused fellowships/assistantships can be used to enlarge the pool and enhance the diversity of high quality STEM Education graduate students.

4. Continue to use the Waterbury Summits to promote STEM Education scholarship by providing additional funding for Waterbury Summits that address issues such as STEM Education research agenda (the key STEM Education research problems referred to previously), studying how the College's STEM expertise might be leveraged to impact STEM Education policy by impacting governmental entities in ways that go beyond the current influence that is exerted through College faculty members' roles in national and international professional organizations, and the like.

Connection to the 7 Diversity Challenges

1. By preparing teachers to equip students with STEM knowledge and skills that are needed for global economic competitiveness, STEM Education in the college can contribute to developing a curriculum that fosters international/intercultural competence and to developing a broader and inclusive understanding of diversity.

Cross-silo and Cross-college Connections

Potential links with recommendations of the Teacher Education Study Team

1. Research on STEM-related teacher education might be a visible part of the Center for Research on Teacher Education.

2. Ph.D. candidates in the STEM disciplines might be candidates for a minor/cognate area of study in teacher education (e.g., a Biology Ph.D. who aspires to teach science courses for prospective teachers)

Potential Links With Recommendations of the Ubiquitous Computing, Telecommunications, and Science of Learning Study Team and the Teacher Education Study Team

1. Cutting-edge learning environments would enhance STEM-related teacher education. Rather than recommending particular computing tools that would enhance STEM Education, we suggest that the College's programs focus on the goal of developing the capability of teachers and their students to adapt to emerging technologies, as-yet-unknown ones with which they will be working in the future. This requires students not only to learn with cutting-edge tools but also to develop more general expertise that enables them to development fluency with emerging technological tools as they encounter them.

2. Ubiquitous and easily accessible technological linkages with schools would enhance STEM teacher education and research activities.