Report of the Task Force on Science Education
University of Kansas

Prepared for Chancellor Robert Hemenway

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Joseph Heppert, Chemistry
Helen Alexander, Ecology and Evolutionary Biology
Richard Givens, Office of the Provost
James Ellis, Teaching and Leadership
Donald Steeples, Geology
Marylee Southard, Chemical and Petroleum Engineering
Sally Frost Mason, Dean, College of Liberal Arts and Sciences
Kris Krishtalka, Director, Natural History Museum and Biodiversity Research Center
Jim Woelfel, Humanities and Western Civilization Program
Thomas Schreiber, Psychology
John Hoopes, Anthropology
Stephen Shawl, Physics
Susan Gay, Mathematics and Teaching and Leadership
David Darwin, Civil and Environmental Engineering
Valentino Stella, Pharmacy
Keith Russell, Dean, Libraries

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Executive Summary: Task Force Recommendations

Recent reports by prominent academic and scientific institutions raise concern about the health of science education in our nation's universities, colleges and public education institutions. Research universities have been chided for not employing their capacity to provide research experiences for undergraduate science majors, for not fully recognizing their key role in preparing future K-12 science teachers, for appearing to tolerate a lower standard of science teaching than is found for teaching in the humanities and for giving students the impression that science is an elitist and insular profession. Nationally, there seems to be a growing mistrust of scientists and, as evidenced by recent events involving the Kansas State Board of Education, a fundamental misunderstanding of what science is and what scientists do.

This Task Force was charged with examining KU's current activities in science education, science education scholarship and regional science education outreach, and with making recommendations to improve the university's activities in these areas. The Task Force is convinced that KU has established programs that are addressing many of the concerns noted above, although, as a major research university, we are not immune from all of these concerns.

This report is a preliminary summary of recommended actions that meet the Chancellor's charge to the Task Force. The Task Force identified the following core objectives for improving science education at KU. Each set of objectives is linked to a series of high priority recommendations for fostering improvement. The objectives and recommendations fall into the following three broad categories:

1. Initiatives to Foster Science Curriculum Reform

- **Objectives:**

- Non-science majors should complete their years of study with a clear understanding of the nature of science, the process of science and how science influences the environment and human society.
- The scientific community should seek opportunities to improve the content and pedagogy of our science and mathematics content courses.
- Opportunities for undergraduate students to participate in scholarly scientific research should be broadened.
- Faculty whose scholarship focuses on science education and learning should be valued within the promotion and tenure and merit salary systems in their departments and schools.
- Existing science, mathematics and education faculty should be empowered to participate in the reform of science curricula and programs at the university through a

clear commitment from the university to value these activities in the promotion, tenure and merit salary review processes.

Recommendations[i]:

A. *Modify introductory courses (e.g. principal courses for majors and non-majors within the College) in the physical, natural, social, and behavioral sciences to emphasize scientific inquiry along with the factual content of that science. (Short-Medium Term)*

B. *Change the Principal Course Distribution requirement within the College so that students are required to take one course in each of the biological, physical and earth sciences. (Short Term)*

C. *Work to establish an endowment for science curriculum reform that will generate $50,000 per year to support curriculum reform projects. (Short Term)*

D. *Acknowledge educational research and curriculum reform as scholarship in considerations of promotion and tenure and merit salary within departments and schools across campus. (Short Term)*

E. *Identify new resources for adding full-time instructional coordinators to science departments with major service loads. (Short-Medium Term)*

F. *Identify new resources for GTAs or undergraduate assistants to improve the quality of science lecture instruction. (Short-Medium Term)*

G. *Expand access to research experiences for science and science education majors at the University. (Short Term)*

2. Initiatives to Support Science and Mathematics Teacher Preparation

- **Objectives:**

- The science disciplines should awaken to their key role in producing tomorrow's leaders in science and mathematics education, and partner with education faculty to implement improved programs in teacher preparation.

- **Recommendations[i]:**

A. *Establish a cooperative working relationship between the School of Education and the College of Liberal Arts and Sciences to explore the development of new curricula and courses needed to serve pre-service science teachers. (Medium Term)*

B. *Provide the School of Education with the resources to complete the Teacher Education Division (TED) design and implement TED in a manner that provides opportunity for recognition and career enhancement for those who undertake this significant task. (Medium Term)*

3. Initiatives to Foster Science Education Scholarship and Public Education

➢ **Objectives:**

- The entire scientific community should look for opportunities to expand the university's excellent record of science education scholarship, public education and outreach.
- The scientific community should seek opportunities to improve the physical environment in which science courses are taught.

➢ **Recommendations[i]:**

A. *Establish a university-recognized center or institute to promote science and mathematics education scholarship, reform and public education. (Short-Medium Term)*

B. *Seek the addition of several new science content and new science education faculty members who have proven records of scholarship and leadership. (Short Term)*

C. *Establish a new science teaching building project as a key component of the upcoming endowment drive, and seek support for this project from major foundations and other potential financial donors. (Medium-Long Term)*

D. *Pursue the acquisition of new resources, facilities and properties that increase the university's opportunities to engage in science education and science outreach in regional communities and school districts. (Medium Term)*

This self-analysis of science education at KU coincides with a related national climate of introspection. In response to concerns raised by scholarly and policy organizations over the past five years, federal agencies and private foundations have introduced new funded initiatives to 1) improve the science component of general education, 2) develop new fundamental knowledge about how students learn, 3) improve the delivery of science to underserved and underrepresented students, and 4) reform programs for preparing science and mathematics teachers. KU is competing actively for external resources in all of these areas. The Task Force feels that the university has a window of opportunity to build a nationally competitive research focus in science and mathematics education.

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Introduction

We are able to report good news about science education at the University of Kansas. The University has the elements of reforms in place that can make our science and mathematics education programs an exemplar among major research universities. Compared to our peers, we have many unique initiatives in science and mathematics curriculum reform, GTA and faculty development, undergraduate research and K-12 teacher training. These programs should be celebrated. Yet, the Task Force is acutely aware that we make this report in a national cultural climate that is growing increasingly hostile to quality science education.

The effectiveness of science education nationwide has been eroding over the past 30 years.[1] Research universities, including KU, bear part of the responsibility for fostering a growing crisis in science education.[2] Nationally, we are losing the battle to maintain student commitment to science, mathematics and engineering majors.[3] This may be due, in part, to the changing demographics of our student population, but it also stems from student perception of science as an insular and exclusive profession.[4] As scientists and science educators, we complain about the preparation of the students we receive from the public school system without recognizing that we play a key role in preparing virtually all of the teachers in K-12 classrooms. We also appear to be losing the battle to provide every university graduate with a firm understanding of the nature and process of scientific discovery, and the ability to evaluate the social outcomes of scientific policy.[5] The American public seems more estranged from science now than at any other time in our recent history. We all are concerned that there appear to be few cultural forces making credible efforts to reverse these trends.

Within the context of understanding these national issues, we come to the pertinent question for this report: How can we improve science education programs at KU to serve our students and the citizens of Kansas better? To answer that question, we need to understand what science is and how KU influences science education at a variety of levels within the state.

The Character of Science. What exactly do we hope that students graduating from KU will know about science? This is a complicated question considering that the terms *science*, *the nature of science* and *the process of science* mean different things to different people. When envisioning science, most people seem to focus on what scientists actually do. Some scientists design experiments to explore phenomena or examine the validity of hypotheses, some make observations and categorize those observations, while others use mathematical models or computer-based simulations to check the validity of a given hypothesis. Many scientific problems require the use of an eclectic range of approaches for acquiring and analyzing information, while others require a more focused set of tools. Science educators refer to the practice of science as *scientific inquiry*. The

best description of scientific inquiry in a classroom setting is contained in the National Science Education Standards[6]:

> "When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations."

While scientific inquiry is a key element of science, it is only one component of what students graduating from KU must know to achieve scientific literacy. Students need 1) an understanding of the philosophical foundation on which science is built (the nature of science), 2) knowledge about what scientists actually do to gather information and form conclusions (scientific inquiry), and 3) a perspective on how science influences human society and the environment (the social outcomes of science). Key questions raised within each of these three components are outlined below:

The Nature of Science

- What questions can be addressed within the scope of science?
- What constitutes a fact to a scientist? What constitutes a theory to a scientist?
- How does the scientific meaning of the term "theory" differ from the common societal meaning of the term?
- Why is it impossible to prove that a scientific theory is true?

Scientific Inquiry

- Is there a single "scientific method" or are diverse approaches taken within different fields of science?
- What is the nature of measurement? How are facts obtained?
- What are experimental controls, and when and why are they needed?
- How and why are conclusions formed from imperfect and incomplete data? What is the context of such a conclusion in the development of scientific understanding of hypothesis and theory?
- How do scientists learn about historical processes and events that they did not personally experience?

The Social Outcomes of Science

- Why is science important enough to our society that we should make science education central to the education enterprise?
- How does science contribute to the improvement of the quality of life?
- How do scientists address ethical problems raised by their studies?
- As a society, what should we expect from scientists and mathematicians and the knowledge they generate?
- How do advances in science and technology influence each other?

The improvement of science courses can play an important role in providing students the ability to address these questions, but science content courses are not sufficient to address the range of issues raised under the umbrella of science literacy. A consensus must be forged among the sciences, humanities and social sciences that the educational background needed to address these issues should become an essential component of the knowledge base for all KU graduates. The university community must

make a unified effort to ensure that all students are exposed to and understand these concepts.

The Broader Mission of the University of Kansas. The mission of the University of Kansas in science education goes far beyond the issue of science literacy for our graduates. The University of Kansas graduates a significant number of science, mathematics, engineering and pharmacy students, who enter and contribute to the academic and technical workforces both within Kansas and throughout the nation. KU graduates elementary, middle and secondary teachers who, through their professional careers, manifest a great influence on the education of the children of Kansas and the nation. Graduates from KU help fill the ranks of the schools and institutions that provide health care and oversee public health. The University provides continuing education and informal education resources for students and adults in this region of the state. This multitude of roles has caused the Science Education Task Force to take an inclusive view of our responsibility to develop recommendations that will lead to improvements in science education. To set these recommendations in context, we should examine the current nature of the science education enterprise at KU.

Science Education at KU

As we examined science and mathematics education at KU, we were drawn repeatedly to four questions that are crucial for understanding and formulating proposals to improve the existing science education system:

- Who are the undergraduate students served by science courses at KU and what are their motivations for taking these courses?
- What purposes do science courses serve for KU students?
- Who are the "science educators" that provide science instruction for KU students?
- How does the faculty rewards system affect efforts to revise and reform the science education system?

The following sections summarize our understanding of these issues.

Undergraduate Student Majors at KU.[7] Figure 1 shows the majors of students graduating from KU. Approximately 74 percent of these graduates receive a degree in a discipline other than science, allied health, technology, engineering or science education. These non-science majors are an important constituency group that must be served as we make recommendations to improve science education. Because few of these students enroll in advanced science courses, introductory course offerings

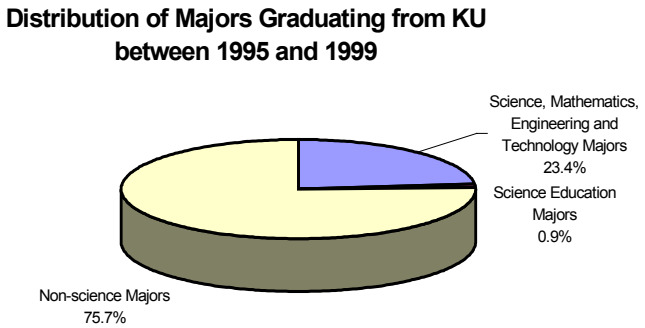

Figure 1

become the primary venue in which they experience science, improve their scientific literacy and modify existing attitudes about science. These students will become a substantial and influential portion of the electorate. During the coming century, citizens will be asked to make ever more complicated decisions about health care, the environment and other national priorities. Many of these decisions will require a sophisticated understanding of science and technology, including the capabilities, limitations and inadequacies of science to address various problems. Providing these students with a strong foundation in the nature of science informs a group of citizens who will contribute to decisions that affect national science policy.

Among the 23.4 percent of KU graduates who are science, mathematics engineering or technology majors, the largest number of students major in biology and pre-medicine (7.9 percent), with professional studies in engineering and pharmacy accounting for another major fraction (7.7 percent and 2.6 percent, respectively). Students pursuing degrees in physical and earth sciences, including chemistry, physics and geology, make up a smaller fraction of science graduates. All science, engineering technology and mathematics majors depend on a strongly cross-disciplinary core of service courses to provide them with the foundation that they need to pursue B.A. and B.S. majors in their own disciplines. This range of advanced courses also prepares Kansas University students for admission to professional schools and graduate study at the increasingly interdisciplinary cutting edge of science.

About one percent of KU graduates can be identified as future K-12 science educators. Over half of these "science education majors" are majoring in elementary education and are not formally identified as science teachers. Although these teachers do not focus exclusively on science content delivery, they do provide the primary source of science instruction for all students in grades K-6. The rest of the future science teachers who graduate from KU pursue careers as middle and secondary school teachers. Both elementary and secondary "science education majors" also rely on a complex web of cross-disciplinary science courses for the science content required for their degrees. All teachers trained in science education are crucially important contributors to the science education enterprise. They are responsible for providing all K-12 students with the foundational knowledge and attitudes toward science that underlie university science instruction. Future science teachers need to observe active learning and inquiry-based science teaching in college science and science education courses so that they can reflect this pedagogy in their own K-12 teaching.

Two major challenges to implementing effective reform in science education are the diversity of cultural experiences and level of understanding that our entry-level undergraduates bring to university-level science and mathematics courses. Because of the state demographics, KU inevitably attracts students from across the spectrum of urban, suburban and rural communities. Although thirteen percent of the state population is composed of individuals belonging to underrepresented groups, recruiting and retaining minority science and mathematics students is difficult. Over the past five years, minority students account for approximately ten percent of the degrees awarded in science, mathematics, engineering, and science education majors at the University of Kansas. This

is higher than the University average in which minority students receive approximately eight percent of all undergraduate degrees awarded. There seems to be a natural opportunity to build relationships that will aid in recruiting more of these students from the Kansas City and Topeka Metropolitan areas. Increasingly vigorous efforts to develop collaborative funded projects involving KU and the Kansas City and Topeka Public School districts may help to increase minority matriculation in science and mathematics majors. Haskell Indian Nations University has a long-standing relationship with the University of Kansas. KU has the opportunity to serve the needs of Native American students who need advanced science and mathematics courses to complete individualized degree programs at Haskell. The University of Kansas has been working with the faculty and administration of Haskell pursuing funds from the National Institutes of Health to allow Native American students to take advanced courses and research experiences at KU. Figure 2 illustrates that the proportion of women receiving degrees in science, mathematics, engineering, and science education at KU over the past five years has remained constant at approximately forty percent. This is strikingly different than non-science related majors, in which women account for approximately 55 percent of degrees granted. Vigorous recruitment programs in the School of Engineering, which have also shown exemplary success in recruiting minority students, has helped to increase the numbers of women entering the engineering program.

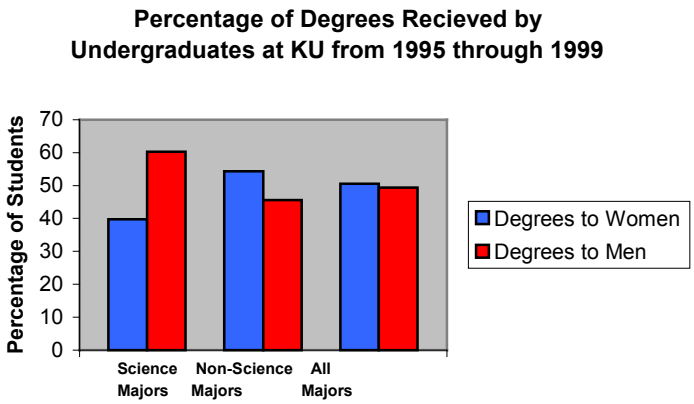

Figure 2

We must also recognize that our student population will always reflect a diversity of learning styles.[8] Science courses at all levels should provide instructional resources that reach both visual and verbal learners, active and reflective learners. Presenting scientific content, problem-solving exercises and testing materials in a manner that reaches students with a range of learning styles will improve the effectiveness of science instruction for a larger fraction of undergraduate students.

Understanding the professional objectives of the students who take our science courses helps us to describe the roles that various courses fulfill for our undergraduates.

Science Courses at KU. If one accepts the general definition of science as the study of the physical or material world based on empirical information, then courses in biology, chemistry, physics, astronomy, geology, and atmospheric science are clearly central to the sciences. Other courses offered in anthropology, geography, environmental sciences, and psychology could also serve as science courses. Courses outside of the sciences can serve as important venues for addressing the philosophy and history of

science, and the role of science in different cultures. Mathematics and computer science are essential disciplines that are closely aligned with the sciences. Outside of the College, the Engineering and Pharmacy Schools, in particular, have a strong focus on science and technology.

Science courses at KU serve three essential purposes. First, a select number of introductory science courses satisfy general education requirements for non-science majors. Such courses usually last one semester and provide a general introduction to the discipline. These courses will be the last experience that many of future KU graduates have with formal science instruction. Consequently, it is crucial that these courses provide students with a solid introduction to science content, a fundamental understanding of the underlying principles of scientific inquiry, a positive attitude toward science and a functional knowledge of the nature and process of science.

The existence of these non-majors courses emphasizes that science is a central component of general education at the University of Kansas, as well as other major universities throughout the nation. For example, the AAAS, in *The Liberal Art of Science: Agenda for Action,* recommends that 50% of instruction in a baccalaureate degree program should be devoted to the liberal arts. Within that, one-fourth should be a liberal education in the natural sciences. Were KU to adopt this standard, students would take 15-16 credit hours of courses in the sciences—two courses more than the current College requirement.

Second, introductory science courses for science majors provide a foundation for further study in the major discipline and cover material that supports advanced study in other disciplines. These courses usually also satisfy general education requirements. The courses are often large, because they have the substantial numbers of engineering and allied health majors entering KU. As these courses serve a significant service role for students in other departments and simultaneously prepare majors to take more advanced courses in the field, faculty are often faced with conflicting priorities in choosing course content.

Finally, advanced science courses principally serve the majors in that science discipline, but also broaden the content background of senior undergraduates and advanced graduate students in other sciences, engineering and pharmacy. These courses are usually structured to deliver the maximum content to committed science, engineering and technology majors.

Having examined the general objectives and student populations in a range of science courses at KU, we also need to understand who is teaching these courses.

Science Educators at KU. Science educators at KU adopt a variety of roles, all of which are important in understanding and improving student learning. The vast majority of KU's science educators are in science departments, although faculty in the Schools of Education, Engineering and Pharmacy make important contributions to the formal education of undergraduate student population. Faculty members from all of these

units also participate in the informal education of both K-12 students and the public about science content and the nature of the science.

The majority of KU's science educators are scientists who pursue world-class scholarship in their own disciplines in addition to providing excellent instruction to undergraduate and graduate students. These individuals adopt the role of science educator as a natural part of their university responsibilities in research, teaching and service, and as part of their mission to mentor graduate students. A smaller number of scientists make understanding how students learn and how to communicate science content more effectively the foci of their scholarship.

A still smaller group of science educators at KU are in education departments. Some of these individuals focus on the preparation of future K-12 science teachers, while others study the nature of student learning and examine the philosophical underpinnings of science.

Science faculty members partner with staff persons and graduate students who are also an integral part of the science education enterprise at the University of Kansas. Nationwide, the trend at research universities has been to increase the number of temporary and semi-permanent staff persons who teach undergraduate science courses. This increased reliance on non-tenure track teaching staff in part stems from a lag in replacing faculty lost during the early- and mid-1990s. The number of staff lecturers in science departments at the University remains small, although departments are struggling more than ever to meet their current teaching commitments. Many staff persons at KU fulfill important instructional support roles other than that of the primary instructor in a course. These individuals are an invaluable aid in providing quality instruction to hundreds of undergraduate students.

This diverse collection of science educators has a remarkable range of knowledge and capabilities about effective methods in science instruction. We believe that science instruction at KU will benefit as these individuals share their insights and collaboratively plan methods for improving science education. The Center for Teaching Excellence has been instrumental in beginning discussions to bring these individuals together for informal sharing sessions. Such efforts are commendable and we hope that they will expand in coming years.

All of these science educators share a common concern with how their professional efforts are evaluated and rewarded. The faculty rewards system plays a key role in defining how faculty invest their time and what they view as being valued by the university.

Science Education and Curriculum Reform, and the Faculty Rewards System. The faculty rewards system at the university directly influences the quality of science education, because the systemic improvement of science education requires the collaboration of faculty from very different academic backgrounds in a wide range of activities. These reform activities can lead these teams of faculty to

- Participate actively in increasing the diversity of the students entering science and science education
- Revise and revitalize introductory courses and laboratories
- Mentor colleagues, graduate teaching assistants and undergraduate instructors in inquiry-based instruction and active learning strategies
- Collaborate with education faculty to deliver relevant science content throughout the courses required for pre-service teachers
- Deepen ties with regional two-year and four-year colleges that provide introductory instruction and are traditional feeder institutions for graduate programs at the University of Kansas
- Develop close ties with school districts to deepen the content knowledge of in-service teachers, change the cultural environments of schools to support active learning and inquiry-based learning approaches and reach out to K-12 students

As we begin the systemic improvement of science education, we need to affirm that scholarship and education are not independent endeavors, in spite of the artificial distinctions often drawn between them. Every scientist and mathematician understands that effectively communicating their scholarly products to their peers is central to the progress of his discipline. In a similar manner, effectively communicating both the content of a discipline and the nature of the scholarly process in that discipline to undergraduate students is essential to the education of aspirants in the discipline. The education of undergraduates occupies a central position in the public's understanding of the role of public universities in society. Innovation and excellence in education need not come at the expense of excellence in scholarship, nor should carefully crafted plans to improve the quality of undergraduate education precipitate an inevitable decline in the quality of scholarship.

It is critical that science faculty participate with and, in some cases, partner with science education faculty in accomplishing these tasks. Reform cannot be initiated and implemented by external consultants or hired experts. Faculty will not embrace curriculum change without first establishing a strong sense of ownership of the reform process.

Yet, the current faculty rewards system is often a disincentive to participation in curriculum change activities. Like all research universities, the promotion and tenure system for scientists at KU is very sensitive to externally reviewed scholarship and external funding. Most colleagues would advise untenured junior faculty and even un-promoted associate professors, to avoid substantial commitments that might be perceived as distracting their attention from "research". Another example of how concerns focused around promotion and tenure can influence curriculum redesign is unfolding in the School of Education. The current design of the School's new Teacher Education Division has reached a stage where faculty members are asking pointed questions about how joint appointments in this new division will affect their professional development. While all of the faculty members in the School are committed to improving teacher education, many individuals are concerned about whether the work they perform in developing new courses and the possible increase in teaching time required to maintain cooperative,

interdisciplinary courses will be recognized and rewarded within the traditional University promotion and tenure system.

While the University clearly cannot pursue a wholesale change in promotion and tenure policies in response to needs for the reform of science education, it can define how curriculum reform can play in the scholarship of individual participants, encourage units to adopt an expanded view of scholarship and provide faculty with concrete incentives to participate in important reform efforts.[9]

Recommendations for Overcoming Barriers to Improved Science Education

The Task Force identified the following list of high priority recommendations for improving science education at KU. Each of the recommendations outlined below includes a brief statement of the needs driving the recommendation and a brief description of the anticipated benefits of implementing the proposed reform. The recommendations fall into the following three broad categories:

1. Fostering Science Curriculum Reform

Modify Introductory Science Courses to Emphasize the Process of Science. Given that all students in the College and most students in professional schools are required to take several courses in the physical, natural, social and behavioral sciences, bringing about change in introductory science courses is the most efficient way to meet the general education needs of large numbers of KU students. A major thrust of national science education reform efforts is to ensure that curricula provide students with an understanding of 1) the nature of science as a way of knowing, 2) the processes through which scientists collect and analyze data and draw conclusions from that data, and 3) the ability to understand and evaluate the social outcomes of scientific research and science policy. Collectively, these characteristics embody scientific literacy in the public. Unfortunately, the degree to which these topics are covered varies widely among introductory science courses and among individual instructors. Often, there is little conscious effort to include this material in the undergraduate experience. We may be missing our last chance to provide future citizens with the tools they need to make informed decisions about science. In order to ensure that all students graduating from KU receive an adequate understanding of the nature of science, the university should encourage faculty to

A. *Modify introductory courses (e.g. principal courses for majors and non-majors within the College) in the physical, natural, social, and behavioral sciences to emphasize scientific inquiry along with the factual content of that science. (Short-Medium Term)*

Departmental curriculum committees are the logical entities to examine existing introductory courses for material related to the nature of science. They are also the most appropriate units for recommending curriculum change to fulfill this objective. This focus on the nature of science is not intended to downplay the importance of factual scientific

knowledge, but merely to reflect the tendency of most traditional science courses to emphasize scientific facts almost to the exclusion of a treatment of the nature, processes and outcomes of science. Indeed it is important to achieve a balance between learning scientific fact and integrating conceptual scientific principles. This recommendation can be implemented through the modification of existing courses, although the Task Force would also welcome the creation of new courses intended to fulfill this need. Departmental curriculum committees need to be furnished with materials providing the rationale for nationwide attention in this area, and with resources to acquaint faculty members with methodology for incorporating the "process of science" into their own disciplines.

The current Principal Course Distribution for the B.A. degree in the College requires that students take one course from three of the four divisions of Natural Science and Mathematics: Biological sciences, Earth sciences, Mathematical sciences and Physical sciences. We are concerned that students can graduate from the University having taken a course in only two out of the three major sub-disciplines of the sciences. Because of these courses play a central role in the general education of non-science majors at the University, we recommend that the faculty

B. *Change the Principal Course Distribution requirement within the College so that students are required to take one course in each of the biological, physical and earth sciences. (Short Term)*

This objective could be accomplished by dropping the Mathematical Sciences requirement from the Principal Distribution Courses. However, given the foundational nature of mathematics in the scientific disciplines and society, we strongly disfavor this option. Instead, we recommend that the Principal Course Distribution requirement be amended so that undergraduates take one course in each of the four divisions of the Natural Sciences and Mathematics. Students should also be required to take more laboratory courses in the Natural Sciences, if it is possible to accommodate the additional credit hours in the requirements for the B.A. degree. In order to obtain maximum benefit from this recommendation, the lecture and laboratory components of natural science principal courses should be modified to emphasize the methods and processes of science, as they are used in that particular field. The professional schools should review course distribution requirements to determine if students are obtaining at least some broad background in the sciences.

Incentives for Faculty Involvement in Curriculum Reform. The reform of science courses with significant enrollments is a time and resource-intensive endeavor. This is particularly true when significant changes in pedagogy and technology are included in the course reform. Faculty members who have heavy commitments in science scholarship need significant support to participate in curriculum revision. Resources are needed to provide these faculty members with an incentive to participate in curriculum reform. This support can take the form of release from teaching, but more often will also include materials, summer support and support for graduate or postdoctoral co-workers. These resources allow faculty to become deeply involved without negatively impacting their research productivity. While some of this support can and should be sought from external funding agencies, these sources are always limited and are unlikely to be

obtained quickly enough to produce significant changes in the culture of science curricula at KU. In response to this challenge, KU should, during the upcoming university endowment drive,

C. *Work to establish an endowment for science curriculum reform that will generate $50,000 per year to support curriculum reform projects. (Short Term)*

This objective is sensible because these resources can provide matching funds for curriculum reform proposals, studies of need, seed money for initiating reform efforts and resources to provide release time for faculty to pursue curriculum reform. Establishing this fund as a permanent endowment reflects the reality that curriculum reform is an ongoing priority need. In addition, if the need for the reform of science and mathematics courses becomes less immediate, resources from this fund will be available for undertaking other curriculum reform projects.

Significant commitments of faculty time to curriculum reform projects need to be planned, recognized and valued as scholarship in the promotion and tenure and merit salary review processes. This implies the need for an attitudinal change on the part of both the university community and the faculty member involved in the reform project. It is unreasonable to expect faculty to willingly participate in the consuming work that will be required to reform science and education curricula if this work is to the detriment of their professional advancement. Nor can we expect a few "education hires" to single-handedly change the culture of teaching in every department. Valuing curriculum reform efforts need not reflect a massive change in the culture of promotion and tenure for the university, but it may require the modification of the culture of merit salary and promotion and tenure evaluation within individual departments. To accomplish this objective the university should

D. *Establish a clear guideline considering educational research and curriculum reform as scholarship both within science discipline departments and within the School of Education. (Short Term)*

Clear principles exist that can differentiate between major pieces of scholarship and minor scholarly efforts. Educational scholarship that is presented in national forums and in refereed journals clearly shows evidence of quality and a scholarly outlook. External funding, when such funding is reasonably available, is clear evidence of the quality of the conceptualized scholarship. Curricular materials and other products employed in curricular reform are evidence of genuine scholarship, particularly if those products break new ground in reforming the culture and practice of the field. These materials should also be externally reviewed. We need to lose our cultural fear of rewarding faculty for producing innovative new textbooks and educational resources. Finally, when individuals are involved in an extensive collaborative project, we need to recognize those individuals in proportion to their contributions to a final product.

Support for Faculty Teaching Large Lecture Classes. During the last 15 years, the science, mathematics and engineering faculty at KU have assumed increasing research commitments. A full 25 percent of the remaining faculty will reach retirement age within the next five years. These retirements will leave an even greater fraction of the faculty with substantial research commitments. At the same time that more of the faculty involved in teaching large service courses become research active, active learning

pedagogy, technology in education and student and peer assessment of teaching have become more prevalent. Teaching science and mathematics today is more complicated and challenging than it was twenty years ago. The intensity of competition for science and mathematics research funding has increased markedly over the same period. Current time demands in lecture classes induce faculty to restrict graded homework and eliminate illustrative lecture demonstrations. Unlike our peer institutions, many large science courses at KU are taught only in a large lecture setting, without small group discussion or laboratory sections. If we expect faculty to enhance the effectiveness of mathematics and science teaching while maintaining high competitiveness in research, we need to identify additional resources to assist in large lecture classes. In order to accomplish this instructional goal, the university should

E. *Identify new resources for adding full-time instructional coordinators to departments with major service loads. (Short-Medium Term)*
F. *Identify new resources for GTAs or undergraduate assistants to improve the quality of instruction. (Short-Medium Term)*

This initiative could be presented to the legislature as an opportunity to provide value-added educational opportunities for mathematics and science students. Instructional coordinators and student assistants can provide assistance with technology, lecture demonstrations, tutorial (or discussion) sessions and graded homework. Instructional coordinators can also maintain records of instructional resources, testing resources and visual aids used in large enrollment courses. This will provide instructional continuity from year to year as the responsibility for these large courses is passed between faculty members. Small group learning experiences would improve the environment in large introductory science courses for all students, but may have the greatest benefit for students who are at-risk for failure. For example, a "Biology Support Program" was implemented in the introductory biology course at KU in 1995. This program provided group discussion sections and tutoring for at-risk students, who were identified by low scores on ACT and SAT tests. "At-risk" students who participated in the program had a final course average of 70.1 percent ($\pm$ 12.0 percent), while non-participating "at-risk" students had a final course average of only 48.6 percent ($\pm$ 13.4 percent). Additional GTAs or trained undergraduate assistants could demonstrate how group-learning experiences would increase the retention of these students in introductory courses. After the effectiveness of this program is established, the university could approach the legislature for funding to expand these programs. Departments receiving additional GTA or undergraduate assistants would document how these individuals provide added educational opportunities for their students.

Providing Greater Access to Research Experiences for Undergraduates. Research experiences for undergraduates often become the pivotal experience in convincing students to pursue advanced study in the sciences. Research in a world-class laboratory is the most eloquent expression of the excitement of scientific research. Such experiences are not only important for science majors, but can allow future teachers to more accurately describe the true nature of the scientific enterprise to their K-12 students. The University of Kansas already has programs that allow some of our undergraduates to participate in research during either the academic year or the summer. Some of these programs are funded through the University Honors Program, while others are funded by

grants from the National Science Foundation and the National Institutes of Health. Programs that bring undergraduates onto the KU campus for research experiences from other colleges and universities have the added advantage that they become a vehicle for recruiting excellent students into our graduate programs. We are convinced of the value of these experiences for our undergraduates and so we urge the University to work to

G. *Expand access to research experiences for science and science education majors at the University. (Short Term)*

Individual faculty members and departments, and consortia of departments can contribute to this effort by seeking funding from federal agencies that support undergraduate research. The University can support undergraduate research by seeking resources to increase the stipends offered through the Honors Program's Undergraduate Research Awards. Competitive summer stipends offered by federally funded summer research projects are approaching $3,000, which is almost twice the stipend offered under the current University awards program.

2. Supporting Science and Mathematics Teacher Preparation

Support the School of Education's Teacher Education Division Redesign. The School of Education is pursuing a comprehensive redesign of the teacher education program through the formation of a new Teacher Education Division (TED). This program holds the promise of continuing the School of Education's national leadership in teacher education reform. This new structure will place students in cohorts whose course work focuses on issues of teaching and learning within a particular license area throughout each year of the program. The cohorts will engage in field experiences (pre-teaching experiences) in the schools and the community during each semester of study. Material covered in content courses will be strongly linked to the context of these field experiences. TED also envisions building a closer partnership between the content disciplines in the College of Liberal Arts and Sciences and the faculty members in TED who teach methods courses. In establishing these relationships, the School hopes to prepare teachers with a stronger and more appropriate grounding in content and foster teaching in the content disciplines that models active learning and inquiry-based pedagogy. To accomplish these objectives, the University should seek to

A. *Establish a cooperative working relationship between the School of Education and the College of Liberal Arts and Sciences to explore the development of new curricula and courses needed to serve pre-service science teachers. (Medium Term)*

It is possible that the TED redesign will recommend the creation of new science content courses to serve pre-service elementary teachers. These courses would mirror those taught in the mathematics department for elementary educators. Examples of curriculum revisions currently being evaluated by TED for secondary science educators include

- Completion of course requirements comparable to a B.A. major in the science field they will teach (biology, physics, chemistry, or earth/space science).
- Completion of an undergraduate science research experience.
- Completion of a capstone course that addresses issues that integrate understanding of the history/nature of science, the major conceptual ideas in a science discipline, and the teaching of science.

- Completion of a capstone course by secondary mathematics educators that addresses major conceptual ideas in mathematics and relates them to teaching middle/secondary mathematics.

The TED redesign is stretching the personnel resources of the School. Both administrators and faculty have invested significant effort in establishing a vision for the future of teacher education. The new program embodied in TED prepares teachers who will approach their profession with a solid content background, a knowledge of children and how children learn, a vision of schools grounded in current practice and a flexible, reflective approach to instruction. This vision requires a clear commitment from the university administration to provide the resources needed to launch this endeavor. To bring the TED design to fruition, the university should

B. Provide the School of Education with the resources to complete the TED design and implement TED in a manner that provides opportunity for recognition and career enhancement for those who undertake this significant task. (Medium Term)

As has already been noted in this report, maintaining forward career momentum while working in teacher preparation is a challenging task. Among the tasks facing participants in TED are 1) developing new interdisciplinary courses and implementing those courses at off-campus sites, 2) consulting with content faculty in the College about modifying existing courses or creating new courses to serve pre-service teachers, and 3) satisfying the teaching research and service requirements of two units: their home academic department and the Teacher Education Division. It seems possible that this ambitious project will increase the participation of personnel in the School of Education in the teacher education endeavor. All faculty members need to be provided with equitable teaching and service loads during and after the establishment of TED, recognizing their need to continue to produce scholarship in order to continue on an appropriate career advancement curve. Providing the School of Education with resources to allow release time for faculty heavily involved in the formative stages of the programs is one mechanism for accomplishing this goal. Supporting the School of Education as it regularly evaluates faculty workloads during the transition to the TED structure and as it establishes promotion and tenure criteria that reward faculty participation in the evolution of TED is crucial for the success of this endeavor.

3. Fostering Science Education Scholarship and Public Education

A Science Education Center or Institute as a Vehicle for Promoting Interdisciplinary and Inter-institutional Research. True interdisciplinary research is difficult to foster and maintain. Pressing issues in science education are sufficiently challenging that it is essential for participants from very different academic disciplines to collaborate to devise insightful solutions. KU has a mostly successful history of cooperation and collaboration between different schools and colleges. There is a longstanding cooperation between the School of Education and College of Liberal Arts and Sciences, including several joint appointments, which can be built on in order to promote interdisciplinary research. Providing a framework for interdisciplinary collaboration is important, because innovative collaborative efforts will raise the competitiveness of science education research programs built at KU. We feel that the

most effective method to facilitate such cooperation, take advantage of opportunities to obtain major external funding and support focused curriculum reform in the science discipline departments is to

A. *Establish a university-recognized center or institute to promote science and mathematics education scholarship, reform and public education. (Short-Medium Term)*

This entity will assist faculty participants in science education by identifying opportunities to obtain external grant support in science education, supporting collaborative efforts to write competitive grants and facilitating the administration of interdisciplinary projects. The Center or Institute would act as a campus-wide resource in implementing and obtaining resources for curriculum reform. The unit would also be a liaison between the chairs of content discipline and the TED in the School of Education regarding the implementation of curriculum reforms needed for preservice teachers. This unit would also articulate the roles that individual faculty members play in collaborative projects. Finally, the Center or Institute would provide a vision of the quality and scope of science education projects to individuals and entities outside of the university.

Achieving a Critical Mass of Educational Researchers. As the Task Force developed the NSF Centers for Teaching and Learning (CTL) proposal and NSF Research Opportunities for Learning Enhancement (ROLE) pre-proposal, it once again became apparent that our long-term goal of achieving national and international recognition in science education is hampered by the limited pool of faculty members whose scholarship focuses on science education. Most of the participants currently involved in funded educational research are fully occupied in teaching, research and service activities to such an extent that they are reluctant to adopt additional responsibilities. The prospect of actually implementing a new center, like the CTL project, raises serious concerns about staffing. We are also acutely aware that reviewers of major proposals focusing on science education may judge that KU does not have the critical mass of faculty members needed to develop a successful center. A significant fraction of the faculty members interested in or involved in science and mathematics education have other major scholarly commitments to their own research programs. Establishing a Center or Institute for Science Education will provide a supporting structure for obtaining major programmatic external funding and facilitate enhance the productivity of these educators. However, a significant increase in our current activities will require additional faculty and staff who can focus their efforts on science education and scholarship. In response to this need, the university should

B. *Seek the addition of several new science content and new science education faculty members who have proven records of scholarship and leadership. (Short Term)*

It is important to add experienced faculty who can adopt leadership responsibilities. The addition of this cohort of scholar-leaders would be justified by obtaining just one major externally funded project. We are currently competing against institutions that have made science education a scholarly focus area by attracting four or five science educators to their faculty ranks. At the University of Kansas, individuals with scholarly interests in science education can be absorbed into both science content disciplines and the School of Education. Adding such scholars in selected science disciplines would act as a catalyst

for education reform activities within those departments, though each would have to involve other faculty within their department to generate a lasting systemic reform. These individuals can benefit both the College of Liberal Arts and Sciences and the School of Education through participation in courtesy appointments and co-teaching responsibilities arranged between the Deans of the units.

Identifying Resources to Construct the New Natural Sciences Laboratory Teaching Facility. Many of the laboratory facilities for introductory science on the KU campus are nearly half a century old. These facilities were not designed to accommodate interactive student learning, to facilitate group interactions in conjunction with the laboratory experience, to introduce modern technology into the laboratory experience, to make provision for adequate ventilation and storage for chemicals, biological samples and equipment, and to provide students with ready access to the information technology that is becoming a more and more prevalent part of the academic experience of students at KU. The science disciplines are united in the need to push forward the initiative to build a new Natural Sciences Laboratory Teaching Facility north of Haworth Hall. The university has provided strong support for this effort, placing the construction of the building at the top of its priority list for new academic building projects on the KU campus. In order to move the process forward, we encourage the university to

C. *Establish this building project as a key component of the upcoming endowment drive, and seek support for this project from major foundations and other potential financial donors. (Medium-Long Term)*

The Task Force is actively pursuing through University channels initiatives that include contact with major foundation donors seeking support for the construction of the Natural Science Laboratory. We encourage the university to fast track these efforts and establish a working group including personnel from the College, Endowment Association and Administration to develop a strategy and a timeline for obtaining resources and beginning the building project.

Responding to New Opportunities for Improving Public Education and Outreach. Science educators at KU participate in a range of formal and informal public education and outreach events that reach thousands of children and adults throughout northeastern Kansas. Many of the university's formal outreach events are coordinated through the Natural History Museum. The Museum's formal outreach events touch hundreds of K-12 students and teachers, and citizens each year. The reputation of the Museum in education and research brings recognition to the university far beyond the borders of the state. Science departments and individual science faculty and staff engage in outreach to public schools and citizen groups. These efforts contribute to the reputation of the university as an educational resource to the community and state. Informal education and outreach efforts are also a valuable opportunity for science and science education majors to experience the joy of communicating science to children.

D. *Pursue the acquisition of new resources, facilities and properties that increase the university's opportunities to engage in science education and science outreach in regional communities and school districts. (Medium Term)*

KU has opportunities to extend the range of facilities and properties that serve the function of community science education. The Natural History Museum is revamping and

expanding its science facilities for science teaching. This project has the opportunity to serve hundreds of students and teachers per year and act as a focus for science education research. The Kansas Biological Survey is interested in acquiring an additional parcel of land adjacent to the Kansas Ecological Reserves north of Lawrence. This reserve is intended as a community outreach and research center. This resource would provide a venue for K-12 students to participate in directed nature walks and ecological research projects within minutes of the Lawrence, Lecompton and Baldwin Schools. This site has the potential to become an important resource for science education projects and could become a focus in seeking additional external funding. The on-campus Clyde W. Tombaugh Observatory is another teaching and outreach resource that brings observational astronomy to hundreds of individuals in the Lawrence area. This facility is antiquated and would greatly benefit from being relocated to a lower-light area neighboring Lawrence. The Museum of Anthropology is currently being reviewed in anticipation of the upcoming retirement of its long-time director. This facility will require ongoing support to enhance the effectiveness of its staff at securing external funding for public exhibits and research projects during the transition to new directorship. It is anticipated that the new museum administration will articulate a mission that has continuing contributions to general science education as a primary goal. The University should evaluate these and other opportunities to extend public science education and outreach.

Process: Development of the Task Force Report

Following its inception in November 1999, the Science Education Task Force spent several sessions examining issues facing the university community in science education. These discussions highlighted four areas of concern that became the focal issues examined by sub-committees of the Task Force

Sub-committee #1: Establishing an Institute or Center for Science Education

Sub-committee #2: Presenting the Methods and Processes of Science in Undergraduate Education at KU

Sub-committee #3: Teaching and Learning of Science

Sub-committee #4: Science Teacher Preparation and Professional Enhancement

The sub-committees were charged with examining contemporary issues at KU relevant to their topic area and making recommendations for change to the full Task Force. The sub-committees inevitably found some overlap between their areas of concern. In order to minimize duplication of effort, the chairs of the sub-committees met on a monthly basis to share their progress with other sub-committee chairs.

After two months, each sub-committee produced a report or compendium of products that included recommendations for improving science education at the University of Kansas. The subcommittee chairs met to combine these reports into a

comprehensive draft report. After the initial draft was completed, it and all subsequent drafts were submitted to the full Task Force for comment.

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i. Each recommendation in the executive summary includes an assessment of how long that task will require for implementation (short term, 1 year; medium term, 3-5 years; long term, 5-10 years).

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