

STEM Education PhD Program Proposal

Fall 2007

Executive Summary

A PhD program in Science, Technology, Engineering and Mathematics (STEM) Education is a natural outgrowth of developments at NDSU over more than a decade. The program will build on existing programs and externally funded projects, including existing STEM doctoral programs, major STEM education projects funded through the NSF and NIH, and a successful Masters of Science Education degree program established in the 1990s.

Collegiate and school STEM education positions are difficult to fill nationally. There is considerable unmet demand for faculty with STEM disciplinary and education qualifications and expertise. The proposed STEM Education PhD program will include core and elective course work and seminars in STEM disciplines and in Education while providing flexibility to allow candidates to tailor programs to meet their personal goals for disciplinary and educational course work and research under the direction of their graduate committee. Three new core didactic courses in education will be developed for the program, and existing courses will be used in both the core and elective portions of the degree.

The basic framework is already in place at NDSU, with one doctoral degree recently awarded by Biological Sciences focusing on collegiate science education. A core group of four science and mathematics education faculty members already collaborate with STEM and Education faculty through the Center for Science and Mathematics Education (CSME), providing a group to lead the establishment and development of this STEM Education doctorate. This program will require additional faculty lines, graduate assistantships, support staff, and operating funds. It will be an interdisciplinary program within the NDSU College of Graduate and Interdisciplinary Studies. Faculty on the program's steering committee will be affiliated with the collaboratively funded Center for STEM Education (CSTEME, a suggested new name for the existing CSME)

The program will not only produce new faculty in the high need STEM education area, but will also strengthen the ability of NDSU to submit proposals for extramural funding so as to add to our research and outreach in STEM education at both the K-12 and post secondary levels. Opportunities for doctoral candidates to participate in funded educational projects are both an important component of their graduate studies and an important outreach and service role for NDSU STEM education in North Dakota school systems. The focus of this program on STEM education will also strengthen the instructional responsibilities of STEM units at NDSU, particularly at the undergraduate level.

NDSU STEM Education Ph. D. Program

Need for Program

Student interest. Over the past 10 years we have had individuals interested in pursuing math and science education doctorates who have (a) Pursued a doctorate at another institution in teaching and learning or educational leadership (Individual 1¹, now teaching at MSUM); (b) Pursued a doctorate at NDSU in Occupational and Adult Education or Institutional Analysis while focusing on science or mathematics education (Individual 2 of VCSU, Individual 3 of Northwest Tech, Individual 4 of Devils Lake); (c) Moved to another institution to pursue the science or math education doctorate, then returned to the Fargo region (Individual 5, University of Arizona; Individual 6 University of Minnesota; Individual 7, Purdue). It is common for talented secondary mathematics teachers to pursue a masters degree or study through Minot State University, then not pursue doctoral studies because no appropriate program is available regionally (Individuals 8 and 9, Fargo South High; Individual 10, West Fargo).

Career Opportunities. The demand for faculty with science and mathematics education qualifications nationally is well known. For example, in recent years informal surveys have shown significantly more mathematics education vacancies than new mathematics PhDs. At NDSU, we feel fortunate to find one or two qualified applicants for math and science education faculty searches. This matches the experiences at many other institutions.

This need has been repeatedly recognized by Congress. For example, legislation has recently passed providing new support for individuals pursuing STEM education study in college (AACTE Brief, vol 28 no 9 Sept 2007). The *Chronicle of Higher Education* has published numerous articles about the need for improved science and mathematics education in our colleges (for example, their Aug. 3, 2007 special report *America's Science Test: The Tough Road to Better Science Teaching*).

Special Interest. Nationally, increased prominence—including a significant infusion of federal funding—has been given to the improvement of STEM Education. The NDSU Administration has supported and encouraged us to strengthen our graduate program in this area. This proposed program will contribute to our efforts to increase our funding for research and strengthen research productivity, while training professionals with expertise in STEM Education to meet the needs of the changing population of North Dakota, the region and the nation.

Viability. These programs would not have high enrollments—compared to our other education doctorates—because of the emphasis on advanced study in the sciences or mathematics. It would be reasonable to hope for 2-3 new mathematics education candidates each year, 2-3 physical sciences candidates, and 4-6 life sciences candidates. This balance reflects trends in lower

¹Each individual is a specific person. Names will be provided upon request.

degrees that have roughly equal numbers of math and physical science education candidates compared to biological science candidates.

This program will be likely to have a significant impact on the amount of externally funded research in STEM education at NDSU. Additional STEM education faculty will be expected to actively pursue grants and will have graduate students who can assist with the operation of these projects.

Including the PhD degree, there is an unmet demand for advanced degrees in STEM education. By offering regular graduate courses in this area, we expect to see an associated increase in graduate enrollments at the Masters level in STEM education.

Program Objectives

- Objective 1. Graduates will have strong backgrounds in both education and the STEM discipline. This is already a characteristic of our undergraduate teacher education program, which has disciplinary requirements that are at the highest levels in comparison to undergraduate teacher education programs nationally. (For example, mathematics education at NDSU requires 42 credits of undergraduate mathematics, almost identical in content to our mathematics major. ND ESPB requires only 32 credits for a *major equivalency*.)
- Objective 2. Graduates will have extensive experience working and collaborating with faculty and candidates in associated STEM and Education disciplines. This matches a characteristic of many projects and activities at NDSU over the past 15 years. STEM and Education faculty at NDSU already work collaboratively on a variety of funded projects (for example: NSF-CoMSTeP–mathematics, physics, chemistry, geoscience and biology faculty; NSF-GraSUS–mathematics, engineering, plant science, biology, science education faculty; NIH-Bridges–CSME, biology)
- Objective 3. Graduates and STEM education program faculty will have had experience working on extramurally funded projects and will relate their learning to teaching either at the college or high school level.
- Objective 4. The program will enhance our ability at NDSU to seek additional STEM educational projects with federal and state funding. Existing qualified faculty are already working at capacity on other projects.
- Objective 5. This collaborative program will strengthen ties among STEM and Education academic units on campus and will support increased attention on the teaching and learning of STEM disciplines, particularly at the undergraduate level, at NDSU.

Cost and Resources

Elements of this program are already in place. This primarily reflects two developments over the past 15 years: (a) hiring of mathematics and science education faculty with split appointments in

Mathematics (2 faculty) or Biological Sciences (3 faculty, 2 presently at NDSU) and the School of Education and (b) establishment of the Center for Science and Mathematics Education (CSME), primarily funded through science and mathematics educational grants².

Through the efforts of these STEM educational faculty and other STEM and Education faculty, we have (a) developed relationships with and conducted projects involving the K-12 system and other post secondary institutions and faculty in the region and (b) established opportunities for teachers and other individuals to pursue graduate studies in science and mathematics education.

This ground work means that the new doctoral program is a natural outgrowth and expansion of existing programs. The new program will continue the existing strategy of providing considerable flexibility with a common core in both education and the disciplinary area. The new program is necessary so that (a) we can offer appropriate courses on a regular schedule, both during the academic year and in the summer; (b) have advisors with appropriate backgrounds to guide doctoral research; and (c) obtain funding for significant research projects in STEM education.

The new resources that are required for this program include:

- A program Director—for example, the Director of the CSTEME (Center for Science, Technology, Engineering and Mathematics Education)—at least half time devoted to this program.
- An administrative assistant, at least half time devoted to this program.
- An office, recruitment and operational budget.
- At least three new faculty positions in STEM education. The faculty members will have at least a masters degree or its equivalent in a STEM discipline and in Education, along with a doctorate in one or the other. The suggested initial areas are Mathematics, Physics, and Biochemistry. Additionally, the program should have a faculty member with the recognized position responsibility representing each affiliated department—that is, there is a need for formal representation from Mathematics, Statistics, Physics, Chemistry and Biochemistry, Biological Sciences, Geosciences, Computer Science, Engineering, and the School of

²Existing faculty positions at NDSU with significant involvement in STEM education and associated projects: Professor Donald Schwert, Geosciences and CSME Director; Professor Dogan Comez, Mathematics; Professor William Martin, Mathematics, Mathematics Education and SOE Head; Assistant Professor Lisa Montplaisir, Biological Sciences and Science Education; Assistant Professor Angela Hodge, Mathematics and Mathematics Education; Assistant Professor Gary Ketterling, Science Education and Biological Sciences. These faculty collaborated with Professor Dan Kroll, Chair of Physics on this proposal and will be initial members of the CSTEME Steering Committee along with new hires and representatives of other affiliated STEM and Education units at NDSU.

Education with recognition of this role included in the faculty members' position descriptions.

- At least 9 graduate assistantships that can be used either to support STEM Education grant-funded projects or teaching in STEM or Education (for example, introductory undergraduate science or mathematics courses, undergraduate mathematics or science teacher education methods courses).
- Support for the regular offering of appropriate STEM content courses during the summer that are targeted at masters and doctoral students in STEM education—at a minimum, two mathematics and two science courses each year.
- Current high quality curricular materials for STEM education at the middle, high school, and undergraduate level available onsite (in the NDSU library or in a resource center).
- A laboratory classroom with equipment that represents the current state of the art in mathematics and science education.

Accreditation Requirements

This program will not be accredited directly, but the NDSU School of Education is accredited by NCATE. Those accreditation requirements apply to all programs within the unit. This program will be an interdisciplinary program run through the CSTEME and the College of Graduate and Interdisciplinary Studies.

Relationship of the Program

To the institution.

This program will be an interdisciplinary program directed by a steering committee of faculty who are affiliated with the CSTEME. The Director of the STEM Education PhD program will work with the Director of the CSTEME to ensure that the program has adequate faculty, administrative staff, and other physical and financial resources. Chairs of affiliated departments will ensure faculty representation from their unit in the steering committee and CSTEME. These faculty will be identified by the department chairs with the advice and consent of their Dean. The Director of the STEM Education program is selected by recommendation of the steering committee to the affiliated deans.

As described above, this program is a natural outgrowth of science and mathematics education programs and activities over more than 10 years at NDSU. These activities involve faculty from the colleges of Science and Mathematics; Engineering and Architecture; Agriculture, Food Systems and Natural Resources; and Human Development and Education. Much of this work is coordinated through the existing Center for Science and Mathematics Education (CSME), which is supported by the Colleges of Science and Mathematics and Human Development and Education. Faculty from these colleges have a strong record of major collaborative funded projects aimed at strengthening STEM education at the K-12 and undergraduate levels.

To the System. There are few such programs nationally and none in ND. Presently individuals in ND pursue science or mathematics education doctorates under special arrangements in programs

with an educational emphasis (educational leadership, institutional analysis, adult and occupational education) or through special individualized arrangements in a departmental program such as Biological Sciences at NDSU. Otherwise, candidates must move to institutions in other states and regions.

To the region. There are no STEM education doctorates in the region. There are relatively few science or mathematics education programs nationally with the level of disciplinary expertise envisaged for this program. The expertise we envisage is that our graduates will have the disciplinary expertise necessary to credibly teach regular content courses for majors at least at the undergraduate level.

Relationship to the Roundtable Recommendations

Economic Development Connections. There is a great need for science and mathematics teachers both at the school and post secondary levels. This program will help to meet that demand, both directly and indirectly through the contributions its graduates make to teacher education programs at regional institutions of higher education.

Education Excellence. As described earlier, there are more positions nationally than available candidates with strong qualifications in both education and science or mathematics. Each year, many searches for such faculty fail as institutions compete for the few qualified applicants.

Flexible and Responsive System. As a smaller institution, NDSU already has a culture of collaboration among departments and colleges in STEM education endeavors. This program is designed to be flexible on a common core so that the degree program is tailored to the interests and needs of each candidate. The sharing of core resources will allow us to offer programs that might otherwise not be feasible because of the small number of candidates in a particular discipline (for example, mathematics education). These interdisciplinary perspectives and experiences will be particularly useful in a state where secondary science and mathematics teachers may be the only science teacher in a rural school.

Accessible System. This program will cater to both traditional, full time on-campus students and to teachers and others who wish to pursue the doctoral degree without leaving their current employment. This will be possible through extensive summer study opportunities and evening course work. We also anticipate that elements of the program, such as the STEM education seminar, will be available through distance technologies.

Funding and Rewards. There is a need for identified and funded faculty and staff positions as described previously. The CSTEME requires financial support to conduct the administrative requirements of this interdisciplinary program. Faculty with roles in this program as members of the CSTEME need to have their research, teaching, and service work for this program clearly stated and recognized in their position descriptions. It will be particularly important that significant project work for this program—such as major funded projects involving schools—be

recognized as more than a service role for purposes of promotion and tenure. The Steering Committee of the CSTEME will be invited to provide input for promotion, tenure, and evaluation of faculty hired in support of this STEM education program. It is expected that the Steering Committee will also lead searches for new and vacant positions associated with the STEM Education doctorate.

Sustaining the Vision. The faculty of this interdisciplinary program are trained in both disciplinary content and educational research. A value of this training is the accountability to the relevance and interconnectedness of STEM research on educational practices to the citizens of ND. By providing students with the opportunity to obtain a PhD in STEM education, NDSU will prepare citizens who help to meet the growing need for interdisciplinary specialists.

Program Requirements

This program requires 60 semester credit hours beyond the Masters Degree, or 90 semester hours beyond the Bachelors degree. Candidates must have the Masters Degree or equivalent for full admission to the program. Additionally, by completion of the doctorate, the course work must include either a Masters degree or its equivalent course work in the chosen STEM discipline (this applies if the Masters degree is in education or another related field).

Didactic Courses in Education (minimum 9 credits).

EDUC 7X0 Goals, Content, and Programs in STEM Education (3 cr, *new course*)

EDUC 7X1 Teaching and Learning STEM (3 cr, *new course*)

EDUC 7X2 Research and Assessment in STEM Education (3 cr, *new course*)

Didactic Courses in Statistics and Educational Research (minimum 9 credits).

STAT 725 *Applied Statistics* (3 cr, *existing course*) (Additional existing course options:

EDUC 702 *Statistics in Educational Research* (2 cr) or STAT 726 *Applied*

Regression & Analysis of Variance (3 cr))

EDUC/CNED 776 *Qualitative Research and Program Evaluation* (*existing course*).

EDUC/CNED 779 *Quantitative and Survey Research* (*existing course*). (Additional existing course options STAT 662 *Introduction to Experimental Design* (3 cr.), EDUC 780 *Instructional Models* (2 cr))

Elective Graduate Courses in Discipline and STEM Education (minimum 12 cr).

Didactic courses selected with approval of graduate committee to strengthen preparation in education and discipline.

Educational Research Seminars (minimum 9 cr).

Research seminars should be at least 4 credits/calendar year once the candidate has completed introductory courses.

EDUC 790 *Seminar: Research in STEM Education* (1-3 cr, *new seminar*) (beginning students might attend to learn about the work of advanced students and faculty, earning 1

credit; advanced students would make presentations about their work and related work being conducted by others in the field for 2-3 credits)

Doctoral Dissertation (minimum 9 cr).

EDUC 799 *Doctoral Dissertation* (1-15 cr)

Program Assessment/Evaluation.

There will be four checkpoints in a candidate's program:

1. ***Admission:*** Candidates will include a written statement describing their academic preparation for the program, their interests in STEM education, and their goals for doctoral study.
2. ***Comprehensive examination:*** This is to be taken during years 1-2, upon completion of core education course work. This will be a take-home examination in which students have one week to respond to a series of questions to demonstrate their expertise in educational areas: Teaching, Learning, Curriculum and Research Methods.
3. ***Preliminary examination:*** This written paper will become the research proposal, literature review, and preliminary proposed research design for their dissertation. Upon successful oral defense of this examination before their committee, the candidate will be given dissertator status.
4. ***Final defense of dissertation:*** This oral examination will have public (open presentation or the research) and closed (committee questioning candidate about their research) components. Successful defense of the dissertation is the final requirement of the program.

Additionally, program faculty will each year review the progress of all candidates. Advisors will provide the information about each candidate to the program faculty. This will be a written record that is placed in the candidate's graduate file. It will include a statement about whether or not the candidate is making satisfactory progress toward the doctoral degree with a description of progress made during the past year.

Faculty who are members of the CSTEME will review program activities at least annually under the direction of the Director of the CSTEME. This review will include program courses, progress of candidates through the program, and other program activities such as funded STEM education projects and outreach.

Program Delivery

This will be an on-campus program. Some courses may be offered online or using distance technologies as the program is established and develops.