Proposal to Establish a Ph.D. in Mathematics and Science Education

Middle Tennessee State University

FORM - COVER

Sponsoring Institution(s): Middle Tennessee State University

Proposal: Doctor of Philosophy in Mathematics and Science Education

Degree Designation [or] Type of Certificate: Doctor of Philosophy

Ph.D. (Formal Degree Abbreviation) in Mathematics and Science Education (Title of Proposed Program to be established or impacted)

Concentrations:
Biological Education
Chemical Education
Mathematics Education
Interdisciplinary Science Education

Delivery Site(s): Middle Tennessee State University

Proposed CIP Code:

Proposed Implementation Date: Fall 2009

Cooperative Partners: N/A

For more information contact: Dr. Michael Allen (Name) / 615-898-2840 (Telephone)

Institutional Approval: _____/_____
Signature of President ***Date***

FORMAT - SUM (Summary)

INSTITUTION: Middle Tennessee State University

PROPOSAL: Doctor of Philosophy in Mathematics and Science Education

EFFECTIVE DATE: Fall 2009

PURPOSE (Goals and Objectives):

The purpose of the Ph.D. in Mathematics and Science Education (MSE) is to prepare graduates for positions in colleges and universities where they will conduct discipline-based research and prepare America's next generation of K-12 mathematics and science teachers, as well as for leadership positions in a variety of educational settings. The goals of this program are to prepare students to

- Understand the fields of mathematics and science education in terms of theory and practice, research, curriculum design, and student learning;
- Conduct original research that generates new knowledge about the teaching and learning of mathematics and science; and,
- Assume leadership roles in mathematics and science education, including teacher education, discipline-based research, and curriculum and instruction.

The MSE program requires its graduates to: (1) develop substantial content mastery of mathematics and/or science; (2) demonstrate an understanding of educational theories, research methodologies, and best practices; and (3) conduct discipline-based educational research (DBER) at the interface between the fields of mathematics or science and education. This program aims to produce college-level professors and researchers in mathematics and science education but will also prepare leaders in K-12 mathematics and science education whose jobs require them to perform, evaluate, and integrate the results of research in mathematics and science education into K-12 classrooms. This program will also improve the way K-16 science, technology, engineering, and mathematics (STEM) courses are taught.

This Ph.D. program is consistent with the philosophy of the nationally-recognized "Preparing Future Faculty" program, and supports the development of the 21st century scientists envisioned in Project Kaleidoscope. To insure that MSE graduates are adequately prepared, they will be mentored by faculty members with research expertise in mathematics or science, faculty members with expertise in educational theories and research methods, and DBER faculty with expertise in a specific area of mathematics or science education.

CURRICULUM: The proposed program requires completion of 75 semester credit hours distributed as follows:

Curriculum Component	Hours Required
Program Core	30
Concentration Core	18-19
Electives	14-15
Dissertation	12
TOTAL:	75

No. of new courses: _9_ with _26_ credit hours

NEED:

The groundbreaking report, "Rising above the Gathering Storm: Energizing and Employing America for a Brighter Future," highlighted the critical need to improve K-16 students' competence in mathematics and science. President Bush also noted this need in his 2006 and 2007 State-of-the-Union Addresses, and wide-ranging legislative initiatives such as the America COMPETES Act have recently been passed by Congress. All point to the increasing shortage of qualified K-12 mathematics and science teachers in our nation's schools while also calling for transformation of STEM instruction. Preparing additional teachers without addressing the underlying issues of instruction will not solve the problems associated with mathematics and science education in America. Many of the issues in STEM instruction can only be solved by individuals performing DBER with substantial expertise in a field of mathematics or science and in education and pedagogy. As a first step to solve these content-specific problems, colleges and universities are creating faculty positions for DBER experts. The result is that at present, there are more positions advertised for DBER experts than current doctoral programs in mathematics and science education can fill. This proposed new degree has been developed in response to this widespread need nationwide, and particularly in middle Tennessee and the surrounding region.

IMPACT:

MTSU is uniquely positioned to assume a leadership role in the preparation of the mathematics and science education professors needed to prepare the next generation of scientists and engineers. Recognized as the pre-eminent teacher preparation institution in the state, MTSU is also home to the Tennessee Mathematics, Science, and Technology Education Center (TMSTEC); one of only three recognized STEM centers in Tennessee. Murfreesboro is the home and MTSU the alma mater of Congressman Bart Gordon (D-TN), who is author of the America COMPETES Act. This law authorizes Federal funding to support revision in the teaching of K-16 mathematics and science. Graduates of this program will be positioned to impact K-16 mathematics and science education, not only as college teachers, but also as educational researchers, curriculum developers, mathematics and science coordinators for school districts, and as policy advisors to national boards. This program is consistent with one of MTSU's strategic niches—preparing university faculty who can prepare K-16 teachers. This program also supports the MTSU Academic Master Plan (AMP) since the new doctoral degree is "in an area where the need is critical," is a "new program that addresses needs consistent with the mission of MTSU", and shows MTSU's commitment to "adapt to the changing nature of society, the workplace, and the needs of industry and the professions they serve" (*MTSU Academic Master Plan*).

PLANS FOR ACCREDITATION: N/A

ATTACHMENTS: N/A

FORMAT - PS (Program Structure)

A. Total credits required for graduation: 75 hours (post-baccalaureate)*

* Students entering with a master's degree in mathematics, education, or a science discipline may have up to 15 graduate hours applied after determination (based on the recommendation of the program coordination committee and with the approval of the graduate dean) that the courses are directly equivalent to existing courses in the program curriculum.

B. Residency requirements (if any):

A minimum of two consecutive semesters of full-time study are required.

C. Program Core: Total credits: 30 hours

MSE 7800	Teaching Internship	3 credit hours
MSE 7820	Seminar in Mathematics and Science Education*	1 credit hour
MSE 7840	Special Topics in Mathematics and Science Education*	2 credit hours
PSY 7190	Advanced Cognitive Psychology	3 credit hours
PSY 7280	Psychological Statistics: Regression	3 credit hours
PSY 7290	Psychological Statistics: Anova	3 credit hours
SPSE 7010	Educational Research Methodology	3 credit hours
SPSE 7170	Learning Theories and the Educational Process	3 credit hours
SPSE 7180	Qualitative Research Methods	3 credit hours
SPSE 7220	Advanced Educational Technology	3 credit hours

**Students are required to enroll a minimum of twice prior to candidacy.*

D. Concentration Core: Total credits: 18-19 hours

CONCENTRATION CORE COURSES

Biological Education Concentration Core – 19 credits		
BIOL 6200	Speciation	3 credit hours
BIOL 6330	Principles of Physiology	4 credit hours
BIOL 6450	Advancements in Molecular Genetics	4 credit hours
BIOL 6460	Conservation Biology	4 credit hours
BIOL 6740	Brain Development and Learning Disabilities	1 credit hour
BIOL 7900	Teaching and Learning Biology	3 credit hours

Chemical Education Concentration Core – 19 credits		
CHEM 6100	Intermediate Organic Chemistry	3 credit hours
CHEM 6230	Intermediate Analytical Chemistry	4 credit hours
CHEM 6300	Intermediate Physical Chemistry	3 credit hours
CHEM 6400	Intermediate Inorganic Chemistry	3 credit hours
CHEM 6500	Intermediate Biochemistry	3 credit hours
CHEM 7900	Teaching and Learning in Chemistry	3 credit hours

Mathematics Education Concentration Core – 18 credits		
MATH 6120	Advanced Linear Algebra	3 credit hours
MATH 6170	Sets and Logic	3 credit hours
MATH 6190	Analysis I	3 credit hours
MATH 6320	Mathematical Problem Solving	3 credit hours
MATH 7900	Teaching and Learning Mathematics	3 credit hours
STAT 6602 STAT 6603 STAT 6604	Regression Analysis OR Nonparametric Statistics OR Experimental Design	3 credit hours

Interdisciplinary Science Education Concentration Core – 18 credits *Students who choose this concentration must select at least 18 hours (in consultation with their major advisor and dissertation committee) from the courses listed in the three concentrations above or from the courses listed below. Students must take one of the following courses: BIOL 7900, CHEM 7900, MATH 7900, or MSE 7900*		
BIOL 6800	Intermediate Life Science	3 credit hours
MATH 6100	Mathematics for Teachers	3 credit hours
MATH 6330	Algebra for Teachers	3 credit hours
MATH 6340	Geometry for Teachers	3 credit hours
MATH 6350	Probability and Statistics for Teachers	3 credit hours
MSE 7900	Teaching and Learning Mathematics and Science	3 credit hours
PSCI 6020	Investigations in Physical Science	1-3 credit hours
PSCI 6800	Intermediate Physical Science	3 credit hours
PSY 7210	Advanced Psychometrics	3 credit hours
PSY 6480	Advanced Topics in Quantitative Psychology	3 credit hours
PSY 6550	Structural Equation Modeling	3 credit hours
PSY 7580	Multivariate Data Analysis	3 credit hours

E. Electives: Total Credits **14-15 Hours**

	Advised Electives	14-15 credits

In consultation with his or her major advisor and dissertation committee, each student will choose 14-15 credit hours from courses in the College of Basic and Applied Sciences and the College of Education and Behavioral Science at the 6000 or 7000 level.

Students in the first three concentrations should select their electives to ensure that they have completed at least 21 hours of coursework in their field of interest—21 hours with a BIOL rubric for the Biological Education concentration, 21 hours with a CHEM rubric for the Chemical Education concentration, and 21 hours with a MATH or STAT rubric for the Mathematics Education concentration.

F. Research/Dissertation: **12 hours**

MSE 7640	Dissertation Research	12 credit hours

Every student in the proposed Ph.D. in Mathematics and Science Education will be required to undertake, complete, and successfully defend a dissertation that will be interdisciplinary in nature. Students are only allowed to enroll in Dissertation Research following advancement to candidacy after successfully completing a preliminary exam.

G. Admission, Retention, and Graduation Requirements:

The program will be constituted in accordance with the existing university requirements described in the Graduate Catalog.

Proposed Catalog Description Of Admissions Requirements

Admissions will be based on a comprehensive assessment of the candidate's qualifications, and will include an evaluation of the candidate's undergraduate and graduate GPA, Graduate Record Examination scores, and letters of recommendation. Applicants must:

1. Formally apply for admission to the College of Graduate Studies and fulfill all requirements, including submission of official transcripts from all academic work and official scores on the Graduate Record Examination.

2. Have a grade point average (GPA) in previous academic degrees which indicates potential for success in advanced study. Successful applicants typically present a minimum 3.25 GPA in their most recent graduate degree or a minimum 3.0 GPA when entering with a bachelor's degree.

3. Submit scores for the verbal, quantitative and analytical writing measures of the Graduate Record Examination (GRE) which indicate potential for success in the MSE program. Although specific minimum scores are not set, evaluation of scores is an important factor in admission decisions.

4. Provide letters of recommendation from at least three professors or professionals that address the candidate's potential for successfully completing a Ph.D. in Mathematics and Science Education.

5. If they hold a master's degree, have earned at least 24 semester hours of graduate mathematics, science, and/or education credit. Applicants holding only a baccalaureate degree will be expected to have earned an undergraduate degree in an area of mathematics or science and will be expected to earn a master's degree in Science, Mathematics, or Education as they complete the requirements of the Ph.D. Any applicant without a baccalaureate or graduate degree in Science or Mathematics will be required to earn a content master's as they complete the requirements of the Ph.D.

6. International students must also meet the College of Graduate Studies requirement for proof of English language proficiency. This may be accomplished by submission of TOEFL, UMELI test, or IELTS scores that meet COGS requirements, or by successful completion of level 112 of ELS coursework

Candidates who do not meet the minimum requirements listed above but whose application materials indicate high potential for success may be admitted conditionally and would have to meet the conditions of their admission in the time stated to remain in the program of study.

Additional Application Information

1. Students currently in the Doctor of Arts Program in Chemistry at MTSU have the option of applying for admission to the Ph.D. program in Mathematics and Science Education. To do so, they must formally apply to the Mathematics and Science Education program and if accepted may not reenter the D.A. program. Doctor of Arts candidates making the transition to Ph.D. candidacy must satisfy all of the requirements of the MSE Ph.D. program.

2. The application deadline is February 15 for those wishing to be considered for a graduate assistantship in the fall. Late applications may be considered but admission and financial support in the form of an assistantship is not guaranteed.

Retention and Graduation Information

Students must meet the expectations of the University regarding adequate progress toward the degree. Specifically:

1. Doctoral students are expected to maintain a 3.25 minimum GPA for all graduate coursework.

2. Students may not enroll for more than one semester before full admission is granted.

3. Students must complete and submit an approved degree plan by the time 24 credits are completed.

4. Students are expected to consistently enroll and complete coursework in their area of study, making satisfactory progress toward attainment of the degree.

5. During the final semester of coursework students are expected to register for and complete the preliminary examination, which addresses both core knowledge and the student's area of concentration. Upon successful completion of the preliminary examination, the student is admitted to candidacy and proceeds to undertake his/her dissertation research.

6. Once students have begun taking dissertation research (MSE 7640), they must enroll in at least one credit hour of dissertation research each semester until the dissertation is completed.

7. At least two thirds of the credits counted toward the degree must be at the 7000 level.

8. All students will, in consultation with their advisor and or supervisory committee, complete an annual evaluation of progress toward degree completion. Students are expected to maintain satisfactory progress toward degree attainment.

Additional Graduation Requirements

A major goal of the Ph.D. in Mathematics and Science Education is to produce graduates who are prepared to successfully pursue teaching and research careers in academia. To ensure that these students are prepared, they will be required to:

1. Make at least two research presentations at regional, national or international meetings as lead or co-author.

2. Be lead author or make significant contribution as co-author of two articles published, in press, or under review in high-quality peer-reviewed journals.

3. In collaboration with an MTSU faculty member serving as principal investigator, make a significant contribution to the development of at least one external grant proposal.

4. Students who do not already have K-12 teaching experience will be required to complete the MSE 7800 (Teaching Internship) in a K-12 setting.

H. Describe any unique features such as interdepartmental cooperation, collaboration with other institutions, articulation, industry partnerships, etc.

By its very nature, the Ph.D. program in Mathematics and Science Education at MTSU will be based on interdepartmental cooperation utilizing faculty from two colleges (the College of Basic and Applied Sciences and the College of Education and Behavior Science) and encompassing at least six departments within these colleges (Biology, Chemistry, Educational Leadership, Elementary Education, Mathematical Sciences, and Psychology). Faculty and students involved in this program will also be working with the Tennessee Mathematics, Science, and Technology Education Center (TMSTEC), a center whose primary goal is to enhance the quality of mathematics, science, and technology education at all levels in Tennessee. In addition, MTSU is a member of the Oak Ridge Associated Universities (ORAU) and has access to the scientists and resources of the Oak Ridge National Laboratory.

Students in this program will be required to perform interdisciplinary doctoral-level research at the interface of mathematics or science and education that could involve the TMSTECor the ORAU. In addition to interdisciplinary research, all students will share a common core of pedagogical knowledge based on coursework taken in educational research methodologies, qualitative and quantitative educational research designs, educational theories of teaching and learning, cognitive psychology, and instructional technology.

The mathematics and/or science content courses in the concentration core and electives represent the core mathematics and science content knowledge that students will need to become general experts in mathematics and/or science. The psychology and education courses within the program core represent the core pedagogical knowledge that students will need to become experts in educational theory and educational research methodologies. The science-specific education courses (Teaching and Learning Biology, Teaching and Learning in Chemistry,

Teaching and Learning Mathematics, etc.) in the individual concentration cores, the Teaching Internship, the Seminar in Mathematics and Science Education, and Special Topics in Mathematics and Science Education will provide students with substantial experiences related to discipline-based education research.

This combination of a strong core curriculum and discipline specific research will ensure that graduates of the Ph.D. degree in Mathematics and Science Education are well-prepared in their primary science content areas and in the discipline-based education research issues that will be critical to the success of K-16 science and mathematics education in the 21st century.

Interdisciplinary Nature of the Degree

The interdisciplinary objectives of the program are addressed in several ways.

1. Curriculum. The curriculum includes formal coursework in several traditional disciplines in the sciences and education. The science disciplines include biology, chemistry, and mathematics. The education disciplines include educational leadership, elementary education, and psychology. The MSE Coordination Committee will have primary responsibility for ensuring that this curriculum is well-integrated and coherently focused on topics that satisfy the broad educational and research goals of the program.

2. Faculty. The faculty for the program will be drawn from several different departments within the College of Basic and Applied Sciences and the College of Education and Behavior Science. All faculty members teaching courses in the curriculum or supervising doctoral students will be active and engaged researchers who maintain graduate faculty membership. Further, faculty serving as dissertation chairs must hold doctoral-level membership on the graduate faculty of the University (*http://www.mtsu.edu/~graduate/pdf/Graduate_Faculty_Membership.pdf*). Students in this program are assured of qualified and engaged mentorship as all graduate faculty undergo periodic review of their teaching and research credentials in order to maintain graduate faculty membership.

3. MSE Coordination Committee. Primary responsibility for the coherence of the curriculum lies with the MSE Coordination Committee. Together with the academic colleges and the College of Graduate Studies, this committee is responsible for selecting and appointing participating faculty members and for ensuring the coherence of (and adherence to) the program's curriculum and research activities. The MSE Program Coordinator serves as chair of the MSE Coordination Committee.

4. Special Topics. The Special Topics in Mathematics and Science Education (MSE 7840) will consist of regularly-scheduled courses covering topics relevant to students in all four concentrations. These courses will be important components of the educational program, and will introduce new or cutting-edge topics that have not yet been incorporated in the existing curriculum.

5. Seminars. The Seminar in Mathematics and Science Education (MSE 7820) will consist of regularly-scheduled seminar courses covering topics of interest to students enrolled in the mathematics and science education Ph.D. program. These topics will be determined by the MSE Coordination Committee and will be relevant to students in all concentrations. These

courses will also serve as opportunities for exposing students to a variety of perspectives on critical issues related to mathematics and science education.

6. Administrative and Disciplinary Identity of the Program. Because of the inherently interdisciplinary nature of this doctoral program, it will be jointly located within the College of Basic and Applied Sciences and the College of Education and Behavior Science. Strategies to build program identity among faculty, students, and prospective students will include a variety of state-of-the-art mechanisms such as web pages, program blogs, and newsletters, in addition to traditional strategies such as campus visit days and social activities.

7. Dissertation Topic and Committee Composition. The dissertation topic will be decided between the student and his or her major advisor with input and oversight from the student's dissertation committee. The student's dissertation topic must involve original research questions relevant to the teaching and learning of a specific field of mathematics or science. The dissertation committee will consist of at least five faculty members including the major advisor. One of these faculty members must be a mathematician or scientist from the College of Basic and Applied Sciences, one must be from the College of Education and Behavioral Science, and one must be a designated mathematics or science education researcher from either college.

I. Description of New Courses:

BIOL 6800 **Intermediate Life Science.** Three credits. Prerequisite: An undergraduate biology course. Uses a process-oriented approach to the study of life with emphasis on execution and analysis of activities and experiments suited to actual classroom situations. (May not be used for biology majors or minors.)

BIOL 7900 **Teaching and Learning Biology.** Three credits. Provides an overview of how students learn biology and best practices for teaching biological concepts.

MSE 7640 **Dissertation Research.** One to six credits. Selection of a research problem, review of pertinent literature, collection and analysis of data, and composition of the dissertation. Once enrolled, students must register for at least one credit hour of dissertation research each semester until completion. S//U grading.

MSE 7900 **Teaching and Learning Mathematics and Science.** Three credits. Focus on theoretical and practical issues regarding how students learn mathematics and science, best practices for teaching mathematics and science topics, and issues from current literature on the teaching and learning of mathematics and science.

MATH 7900 **Teaching and Learning Mathematics.** Three credits. Prerequisite: Permission of instructor. Emphasis on current issues and trends of mathematics curriculum and their impact on mathematics instruction. Attention given to historical curriculum reform materials as well as standards-based materials. Theoretical as well as practical bases will be studied.

MSE 7800 **Teaching Internship**. Three credits. Teaching of a science or mathematics course under the supervision of an experienced faculty mentor. The mentor will assist the student in preparing a syllabus, developing and teaching the class, and writing and administering assessment activities. The mentor will also provide the student with constructive feedback based on the student's teaching experiences.

MSE 7820 **Seminar in Mathematics and Science Education.** One credit. Required of graduate students specializing in Mathematics and Science Education. This course involves presentations on current issues or research developments in Mathematics and Science Education. May be repeated. [The course CHEM 7820 would be modified to fit this need.]

MSE 7840 **Special Topics in Mathematics and Science Education**. Two credits. Required of graduate students specializing in Mathematics and Science Education. This course provides an overview of current issues related to the teaching and learning of mathematics and science. May be repeated.

PSCI 6800 **Intermediate Physical Science.** Three credits. Prerequisite: An undergraduate course in a physical science. The basic concepts, laws, and principles of astronomy, chemistry, geology, and physics with particular emphasis on the utilization of equipment and supplies available or easily improvised in actual school situations to illustrate these concepts, laws, and principles.

SPSE 7170 **Learning Theories and the Educational Process.** Three credits. Explores major learning theories as well as associated concepts that may be applied in a variety of learning situations including formal education settings, informal learning environments, and work-based settings. Course material will provide knowledge and understanding in order to inform the design of learning environments and instruction. Theories covered may include behaviorism, Bruner's Constructivist Theory, Bandura's Social Learning Theory, Vygotsky's Situated Cognition and Activity Theory, Gagne's Information Processing Theory, and Gardner's Multiple Intelligence Theory.

SPSE 7180 **Qualitative Research Methods.** Three credits. Provides students with the basic skills needed to apply qualitative methods in order to engage in qualitative and naturalistic studies. Includes an exploration of theoretical factors, methods, and frameworks related to qualitative research in education; literature review structure; analysis and application of methods; designing qualitative and naturalistic inquiry studies; appropriate data for qualitative studies; data analysis, coding, and management; and reporting findings. Structured to assist students in designing and implementing a qualitative project. Students must identify a work-based issue and design a study that employs a qualitative approach.

SPSE 7220 **Advanced Educational Technology.** Three credits. . Advanced teaching strategies using technology with on-line instruction, distance learning tools,

computer simulations, applets, webpage construction, presentation software, streaming-videos and multimedia applications. Students will learn how technology tools support teaching and research in both K-12 and college level learning environments.

FORMAT – PJ (Program Performance and Justification)

Institution: Middle Tennessee State University

Program Name: Ph.D. in Mathematics and Science Education

Date: Fall, 2009

A. Accreditation

There are no separate professional accrediting agencies for this particular degree, but the departments of the college maintain affiliation or membership in the major professional associations of their disciplines. Middle Tennessee State University has been accredited by the Southern Association of Colleges and Schools (SACS) since 1962. The Office of Institutional Effectiveness, Planning, and Research coordinates planning and review for ongoing SACS accreditation. The doctoral program will be integrated into the current institutional effectiveness plan of the College of Basic and Applied Sciences and the College of Education and Behavioral Science.

Additionally, this degree program will be reviewed by an external reviewer on a regular five-year cycle in accordance with University, TBR, and THEC policy.

MTSU currently awards Doctor of Philosophy degrees and the development of this new degree has no implications for continuing SACS accreditation of the university.

B. Evaluation Plans

This Ph.D. program will undergo regular and systematic program evaluation. The assessment standards that are most appropriate for measuring the effectiveness and success of the proposed program are

- congruence with and demonstrated achievement of the mission of the University set forth in the goals and objectives of the institutional effectiveness plan for the Ph.D. program and consistency with the University's Academic Master Plan;
- favorable external review;
- favorable exit interviews with students completing the Ph.D. program;
- favorable employment and career patterns for Ph.D. program students, including but not limited to, publication of original scholarly work in the field; and,
- how successfully students are able to meet the research objectives outlined in the graduation requirements, namely:
    - make at least two research presentations at regional, national or international meetings as the lead or co-author.
    - be lead author or make significant contribution as co-author of two articles published, in press, or under review in peer-reviewed journals.
    - make a significant contribution to the development of at least one external grant proposal.

- satisfactory progress of students toward degree completion as indicated through annual assessments of student progress.

The Office of Institutional Effectiveness is responsible for organizing and conducting official evaluations and programmatic reviews at MTSU in compliance with regular five-year external reviews mandated by TBR and THEC. The College of Graduate Studies also conducts a comprehensive review of every graduate program every five years. These reviews are conducted jointly and include development of a comprehensive self-study, student and alumni evaluations, employer data, and an on-site assessment of the program by a recognized expert serving as an external evaluator.

C. Evidence of Demand and Need

The proposed new degree in mathematics and science education has been developed in response to widespread recognition for the need of a new type of doctoral program in mathematics and science education—one that will produce graduates with an expansive set of professional skills that allow them to be agents of change in science and mathematics education as they serve as university science/mathematics faculty and policy advisors to national organizations. Evidence of recognition of this need is found in the recently published call by the National Academy of Sciences (*Interdisciplinary Research Urged*) for academic institutions to foster interdisciplinary research by changing degree programs, policies, and ideologies (NAS, 2004) and the national report entitled "Rising Above the Gathering Storm: Energizing and Employing American for a Brighter Future" (National Academy Press, 2005).

Educational Need: In the past, research and scholarship in the area of teaching and learning in mathematics and the sciences have been traditionally performed by faculty in education departments. While these faculty members are experts in pedagogy, few of them have enough content knowledge in a specific field of mathematics or science necessary to address specific pedagogical issues in these fields. At the same time, faculty in mathematics and science departments are experts in their field of mathematics or science, but few have the training necessary to address specific pedagogical issues in their fields. While both of these groups of professionals are addressing important problems in the teaching and learning of mathematics and sciences, they are often working in isolation without the benefit of the expert knowledge of their colleagues in the other areas of specialization. The need to change the way doctoral institutions educate future academic instructors has also been recognized by such national organizations such as the "Preparing Future Faculty" program (*http://www.preparing-faculty.org*) and Project Kaleidoscope (*http://www.pkal.org*). Other national reports (National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Trends in International Mathematics and Science Study, 2003a and 2003b) show the great deficiencies of science and mathematics education at all levels in the United States. National organizations (including NSF, NRC, and NCTM) that are concerned with this growing problem recommend bringing new voices into the dialog by building a community of scholars that include experts with strong science content backgrounds as well as those with expertise in the research of teaching and learning.

This new Ph.D. program will bring together experts in mathematics, chemistry, biology, education, and psychology to address these issues from a research perspective that utilizes the expertise of a large variety of professionals. In addition to breaking down discipline and administrative barriers that sometimes impede traditional Ph.D. programs, it is anticipated that this collaboration will result in the preparation of scholars who will be experts in designing and conducting research in the teaching and learning of the sciences. Graduates from this program will be in a position to improve mathematics and science education in a variety of ways.

- MSE graduates will have performed cutting-edge discipline-based educational research (DBER) on the teaching and learning of mathematics and science as part of their dissertation. This work will lead to improved instructional techniques and pedagogical materials for the mathematics and science classrooms.
- MSE graduates will have a good understanding of science, technology, engineering, and mathematics (STEM) content, general learning theories and pedagogies based on best-practices, and how these learning theories and pedagogies can be applied to improve STEM instruction.
- MSE graduates will be prepared to become university professors who will provide effective instructional opportunities in mathematics and science for all students, including pre-service K-12 mathematics and science teachers.
- MSE graduates will be qualified to become mathematics and/or science policy advisors to national boards, whose primary goals are to perform DBER research and to use the results of previous DBER research to improve mathematics and science instruction.

Student Interest/Demand: Data collected through the existing D.A. program in Chemistry show there are at least 75 potential candidates who are interested in the Chemistry Education option of the Ph.D. in Mathematics and Science Education (some prospective students have expressed reservations about the D.A. in Chemistry, but said they would reconsider once the Ph.D. program has been approved). These inquiries have come from at least 16 states across the country. The MTSU Biology Department conducted a regional survey of potential candidates, all of whom held master's degrees, to assess interest and need for the proposed concentration among potential biology education students. Over 100 individuals indicated an interest in this option of the Ph.D. program. The Department of Mathematical Sciences at MTSU has collected data informally and found that a number of graduates from MTSU would be interested in obtaining a Ph.D. in Mathematics and Science Education with an emphasis in Mathematics Education. Furthermore, many of these potential students can not or do not wish to leave this region to pursue doctoral study. Research in graduate education conducted by the Council of Graduate Studies has shown that a significant percentage of prospective graduate students are not willing to relocate to pursue their degrees. SREB data (*http://www.sreb.org*) indicates that the demand for this type degree is strong and is unmet regionally. This program will be unique and will attract students from the southeast and beyond.

In addition, as Tennessee, the surrounding region, and the nation respond to this widespread need for more and better-prepared science and mathematics teachers at the K-12 level (NAP, 2005), new initiatives such as those recommended by the national Academies of Sciences and legislated through the America COMPETES Act will encourage thousands of persons to seek careers in science and mathematics education with a corresponding demand for college and

university faculty. Thus, there is clearly student interest in and a long term need for such a program in this region.

Labor Market Evidence: The most recent comprehensive reviews of the status of doctoral programs in mathematics education (Reyes, 2007) and science education (Jablon, 2002) reveal critical shortages in the number of individuals with doctorates in science and mathematics education. Unfortunately, this shortfall coincides with, perhaps, the time of greatest need for individuals with the knowledge, experience and skills to make an impact in these fields. As a result of the national crisis in STEM education, more colleges and universities (as well as national agencies) are creating positions for individuals who are educated in discipline-based educational research (DBER) and who have expertise in a field of mathematics or science and in education. In fact, there are more positions advertised for these DBER experts than the current doctoral programs in mathematics and science education can fill with their graduates (Reys, 1999; Reys, 2000; NCLB, 2001; Reys, 2002; Ashman, 2004; Reys, 2006).

A recent search of the *Chronicle of Higher Education (CHE)* and *Chemical & Engineering News* (*C&EN*) job postings revealed at least 70 chemistry/science education faculty positions for which graduates from this program with the chemical education concentration would be qualified. Of these positions, 18 of them (25%) required the candidate to be involved in chemical education research (the others were for community college instructors, general chemistry coordinators, or laboratory coordinators). During the same time period, the existing chemical education programs in the nation produced fewer than 15 graduates. A recent search of the job postings in the *CHE*, *C&EN*, and a chemical education list-serve run through the Miami University of Ohio showed 185 chemistry/science education faculty positions for the period of January-December 2006. Of these positions, about 40% required the candidate to be involved in chemical education research. An article in *C&EN* pointed out that during this same time period 7% of chemists spent a majority of their efforts in the chemical education specialty while just over 1% had any training in this area (C&EN, 2006). Clearly, there is labor market demand for graduates of programs that provide specialized training in chemical education research. Establishing a chemical education concentration within the Mathematics and Science Education Ph.D. will provide MTSU with an opportunity to be a national leader in advancing this critically undersupplied field by establishing the only program of its kind in this region of the United States.

The situation for prospective students who would be interested in the biological education concentration is similar. For both timeframes, the number of biology/science education positions listed in the *CHE* was similar to the chemistry/science education positions. For example, there were 115 biology/science education faculty positions advertised from January-December 2006. In addition, ninety percent of the administrators at the southeastern community colleges surveyed said that graduates of this program would be highly competitive for faculty positions at their institutions. Over the next six years, they expect to advertise for, on average, one such position every other year. Thus, there is an interest in and need for a program addressing issues in biological education research in the southeast. Three programs in the country produce most of the biological education doctorates, and none of these institutions are in this region of the United States.

The number of institutions offering doctoral degrees in mathematics education is greater however, the number of doctoral graduates in mathematics education has averaged less than 100 per year for the past 20 years. In a search of 2000-01 position announcements in mathematics, Reys (2002) found 134 announced positions in mathematics education, and a search of job postings in the *CHE* from January-December 2006 showed 157 mathematics education faculty positions. These results seem to suggest that the article "Doctorates in Mathematics Education: An Acute Shortage" published by Reys (2000) is still very relevant today. In this article, a study of the 48 leading doctoral-granting institutions found that 51% of their mathematics education faculty members are eligible to retire immediately, and 80% will reach retirement age within seven years. Clearly, the demand for mathematics education faculty exceeds the supply and the shortage of mathematics education faculty will very likely worsen in the future.

There is also a need for mathematics and science educators at the college level who are well versed in Mathematics and Science Education from a generalist's perspective rather than a single discipline in mathematics or science. Many of these faculty positions appear in Colleges of Education within the Curriculum and Instruction or Teacher Education Departments, and these faculty members would be in charge of teaching science and/or mathematics methods courses for K-12 teachers. A recent search of the website for Higher Education on February 12, 2009, (http://www.HigherEdJobs.com) showed at least 17 jobs in Colleges of Education for Mathematics and Science Education faculty members with a generalist's perspective and whose job responsibilities would involve teaching mathematics and/or science methods courses and being involved in K-12 teacher preparation. **Societal Need Evidence:** In the "Gathering Storm" report (NAP, 2005), the National Academy of Sciences highlighted the critical need for a higher degree of competence for all students (K-16) in the areas of mathematics and science. President Bush (Bush, 2006) also commented on this pressing need in his 2006 State of the Union Address and outlined the American Competitiveness Initiative, which included several ideas to address this issue (with substantial, proposed funding opportunities). A year later, President Bush again mentioned the need to strengthen the math and science skills of our children to prepare them for the jobs of the future (Bush, 2007). In addition, several bills related to addressing the national crisis in mathematics and science education were introduced in the first weeks of the 110th Congress (2007). These bills include the SPEAK Act (which would mandate the creation of a voluntary core of nation-wide K-12 mathematics and science content standards), the SUCCESS Act (which would provide support to states which chose to upgrade their mathematics and science standards), the Science Accountability Act (which would require that states incorporate the results of the science assessments as well as reading and math scores in their NCLB accountability measures), and the 10,000 Teachers, 10 Million Minds Science and Math Scholarship Act (which would improve teacher preparation and increase the number of qualified math and science teachers). In addition, the America COMPETES Act, which will commit $43 billion for STEM education and innovation, was written by Congressman Bart Gordon (D-TN) and has been passed into law. Clearly, the President and the members of Congress believe there is a crisis in the current state of mathematics and science education and are working to commit funding to improve it. The need for experts in the fields of science and mathematics education to lead these initiatives is critical.

Other Evidence of Need: The Mathematics and Science Education Ph.D. program represents Middle Tennessee State University's opportunity to help Tennessee and the nation address the

STEM education crisis, and it is consistent with one of MTSU's strategic niches (the preparation of K-16 teachers). This Ph.D. program supports the MTSU Academic Master Plan (AMP) since the new doctoral degree is "in an area where the need is critical" (p. 4) and it is a "new program that addresses needs consistent with the mission of MTSU" (p. 9). Additionally, the proposed Ph.D. addresses the specific criteria of the AMP that graduate programs "must adapt to the changing nature of society, the workplace, and the needs of industry and the professions they serve" (p. 8) (*http://www.mtsu.edu/~provost/masterplan/amp.pdf*).

Program Duplication. There is no program of this type in Tennessee. An Ed.D. program in Curriculum and Instruction with concentrations in Curriculum Planning, Elementary Education, Reading, Secondary Education, and Special Education exists at Tennessee State University. A Ph.D. program in the Department of Theory and Practice in Teacher Education exists at the University of Tennessee at Knoxville. This program offers a Ph.D. in Education with a concentration in Teacher Education that has specializations in Mathematics Education and Science Education. The University of Memphis also has an Ed.D. in Instruction and Curriculum. Unlike each of the existing programs, which are located within a college or school of education, the MTSU Ph.D. degree program in mathematics and science education is housed jointly in the Colleges of Basic and Applied Sciences and Education and Behavioral Science.

Additionally, this proposed program is clearly different than those existing programs because it is a research-intensive program that requires strong content knowledge in mathematics and/or science at the graduate level, in addition to expertise in pedagogy and epistemology at the graduate level. This program also differs from the existing programs by including a primary focus on the preparation of mathematics and science education researchers focusing on DBER research studies performed at the interface of the mathematics or science discipline and pedagogy similar to the Ph.D. program in Science Education offered through the College of Science and Technology at the University of Southern Mississippi (an MTSU Peer Institution).

D. Human Resource Needs

It is of paramount interest to the University that doctoral students in this program receive quality education, training, and mentorship allowing them to succeed in their professional careers. As such, the University has made a serious commitment to support this program to ensure its short- and long-term viability and growth. MTSU presently has vibrant graduate programs at the master's level in the primary disciplines represented in the MSE Ph.D. proposal. Additionally, the Department of Educational Leadership has master's and educational specialist (Ed.S.) degrees, and the Department of Chemistry has a Doctor of Arts (D.A.) degree, all nationally competitive. MTSU also has the Tennessee Mathematics, Science & Technology Education Center (TMSTEC), one of only three STEM centers in Tennessee, that provides professional development for pre-service and in-service mathematics and science teachers in the middle Tennessee region. Because MTSU has strong existing programs in the areas of mathematics, science, and education, the University will be able to absorb the teaching and advising responsibilities required for the Ph.D. program in Mathematics and Science Education. Additional resource needs are addressed below.

1. Faculty:

The development of this proposed degree and the selection of concentrations were based upon the expertise of existing faculty within the Departments of Biology, Chemistry, Educational Leadership, Elementary and Special Education, Mathematical Sciences, and Psychology. As such, core faculty members for each proposed concentration have already been identified from the ranks of the MTSU graduate faculty who qualify to serve as doctoral mentors. In addition, the University is currently conducting a nation-wide search for a senior faculty member to serve as the coordinator of this program. As program enrollment increases, it is anticipated that additional faculty resources will be directed to this program. With this in mind, one additional faculty position (mathematics educator) is currently being advertised for fall 2009. These new faculty positions will allow for full staffing of the additional courses currently being developed for this degree program (i.e., MSE 7820, 7840 and Teaching and Learning courses). Additional positions in the future will be supported by increased enrollment. It is expected that potential for participation in the MSE doctoral program will be used as one of many criteria during the recruitment of new faculty in the involved departments and/or disciplines.

2. *Administrative*:

It is critical that this degree program benefit from strong faculty leadership by faculty members involved in and committed to the degree program. In order to accomplish this, the following oversight and support structure has been created.

The Mathematics and Science Education Coordination Committee (MSE CC) is primarily responsible for the coherence of the curriculum and with the overall selection, training, and mentorship of the graduate students. In partnership with the academic colleges and the College of Graduate Studies, this committee is responsible for selecting and appointing participating faculty members and for insuring the coherence of (and adherence to) the program's curriculum. In addition, the MSE CC will meet to determine whether each student's dissertation topic (as approved by the student's dissertation committee) represents original research in mathematics or science education and to formally approve the student's dissertation topic.

The MSE CC will be chaired by the coordinator of the MSE program, who will be appointed by the Deans of CBAS and CEBS. This individual will receive six credits of reassigned time to support recruitment, admissions, and coordination. The department in which this person is tenured will be provided adjunct replacement for the proportionate reduction of teaching service to the department, and the MSE program coordinator will receive a stipend for summer service. In addition to the MSE coordinator, the committee will be composed of the coordinators of the four concentrations. These individuals will also be appointed by the Deans of CBAS and CEBS. The CBAS and CEBS deans or their designees will serve as ex-officio members of the committee. The concentration coordinators will be responsible for communicating information from the MSE CC back to their faculty and for bringing the concerns of their faculty to the attention of the MSE CC. The MSE CC will meet at least once every semester and more frequently as required. These procedures will be re-evaluated on an annual basis.

E. Other Needs for Support

1. Library:

The MTSU library has significant existing resources to support the delivery of the proposed Ph.D. However, to fully support a high quality doctoral program that has at its core a focus on original research in mathematics and science education, additional journal, text, and database subscriptions will be acquired. With this in mind, the proposal includes one-time ($5,000 in each of the first three years) and recurring funding ($10,000/year) to support the acquisition of additional library resources (see Format FP).

2. Instructional Facilities:

The University has adequate instructional, laboratory, and faculty office space to support the creation of this degree. The construction of the new 258,000 ft^2 MTSU Sciences Building (with science research and educational facilities) to be completed in 2011, and a new education building to be constructed on the MTSU campus will significantly enhance the quality and the quantity of available space for this endeavor. Space will be available for mathematics and science education research in the new science building (including interview rooms and a video control room for recording and analyzing student interviews). In addition, research space will be available in an existing science building for the mathematics and science education research once the new science building is occupied. Taken together, the new and renovated research space available in these two buildings will be adequate for the successful implementation of this Ph.D. program.

3. Instructional Equipment:

A Ph.D. program in Mathematics and Science Education needs to be in a position to utilize the latest instructional technologies. The completion of the new science building and the new education building will occur within the first two years of this program, and it is anticipated that each of these buildings will be equipped with state-of-the-art instructional technology equipment that will be used by the faculty and students in this program.

4. Other Needs:

Assistantships are vital to the success of the program in recruiting high potential graduate students. This proposal includes resources to create 18 assistantships at $18,000 per student per year plus tuition remission. Five assistantships will be created in year one, three in year two, four in year three, four in year four, and two in year five.

Other resources committed to this proposed degree include additional funds to offset travel-related expenses associated with dissemination of research results, recruitment of students, and promotion of the degree program. In addition to travel expenses, the University has committed funds specifically for the recruitment of students. This includes web page design, print and promotional media and postage.

FORMAT – SE (Student Enrollment Projections)

Estimate the headcount and full-time equated enrollment and the number of graduates for a complete program cycle.

Year	Full-Time[1] Headcount	Part-time Headcount	Total Year Headcount	FTE	Graduates
1	5	0	5	5	0
2	8	0	8	8	0
3	12	0	12	12	0
4	16	0	16	16	1
5	20	0	20	20	3

FTE is calculated based upon the following assumptions:
[1]Full-time students are enrolled in 9 or more hours.

It is anticipated that several students currently enrolled in the existing Doctor of Arts in Chemistry degree program will apply for admission into the Ph.D. in Mathematics and Science Education program. As a result, front-end enrollment may be slightly higher than what would normally be expected of a new Ph.D. program at start-up. Students in the existing Doctor of Arts program who cannot meet the admission requirements or elect not to apply for the Ph.D. program would have up to seven semesters past the start date of the Ph.D. to complete the D.A. degree (Fall 2011).

It is anticipated that students entering with a bachelor's degree in mathematics or an area of science will take five years to graduate from the Ph.D. in Mathematics and Science Education program. Students entering with a master's or specialist's degree will probably take four years to graduate from this program.

THEC Financial Estimate Form
Middle Tennessee State University
Ph.D. in Mathematics and Science Education

Five-year projections are required for baccalaureate and post-baccalaureate programs and certificates. Three-year projections are required for associate degrees and undergraduate certificates. Projections should include cost of living increases per year.

	Year 1	Year 2	Year 3	Year 4	Year 5
I. Expenditures					
A. One-time Expenditures					
New/Renovated Space	$ -	$ -	$ -	$ -	$ -
Equipment	-	-	-	-	-
Library	5,000	5,000	5,000	-	-
Consultants	-	-	-	-	-
Travel	-	-	-	-	-
Other	-	10,000			-
Sub-Total One-time	$ 5,000	$ 15,000	$ 5,000	$ -	$ -
B. Recurring Expenditures					
Personnel					
Administration					
Salary	$ 14,400	$ 14,400	$ 14,400	$ 14,400	$ 14,400
Benefits	1,200	1,200	1,200	1,200	1,200
Sub-Total Administration	15,600	15,600	15,600	15,600	15,600
Faculty					
Salary	$ -	$ 60,000	$ 63,000	$ 66,150	$ 69,458
Benefits	-	21,000	22,050	23,153	24,310
Sub-Total Faculty	$ -	$ 81,000	$ 85,050	$ 89,303	$ 93,768
Support Staff					
Salary					
Benefits					
Sub-Total Support Staff	$ -	$ -	$ -	$ -	$ -
Graduate Assistants					
Salary	$ 90,000	$ 144,000	$ 216,000	$ 288,000	$ 324,000
Benefits	-	-	-	-	-
Tuition and Fees* (See Below)	42,810	71,921	113,275	158,585	187,329
Sub-Total Graduate Assistants	$ 132,810	$ 215,921	$ 329,275	$ 446,585	$ 511,329
Operating					
Travel	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000
Printing	-	-	-	-	-
Equipment	-	-	-	-	-
Other	10,000	10,000	10,000	10,000	10,000
Sub-Total Operating	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
Total Recurring	$ 178,410	$ 342,521	$ 459,925	$ 581,488	$ 650,697
TOTAL EXPENDITURES (A+B)	**$ 183,410**	**$ 357,521**	**$ 464,925**	**$ 581,488**	**$ 650,697**

*If tuition and fees for Graduate Assistants are included, please provide the following information.

Base Tuition and Fees Rate	$ 8,562.00	$ 8,990.10	$ 9,439.61	$ 9,911.59	$ 10,407.16
Number of Graduate Assistants	5	8	12	16	18

II. Revenue

	Year 1	Year 2	Year 3	Year 4	Year 5
Tuition and Fees[1]	42,810	71,921	113,275	158,585	187,329
Institutional Reallocations[2]	140,600	285,600	351,650	422,903	463,368
Federal Grants[3]	-	-	-	-	-
Private Grants or Gifts[4]	-	-	-	-	-
Other[5]	-	-	-	-	-
TOTAL REVENUES	**$ 183,410**	**$ 357,521**	**$ 464,925**	**$ 581,488**	**$ 650,697**

Notes:

1. In what year is tuition and fee revenue expected to be generated and explain any differential fees. Tuition and fees include maintenance fees, out-of-state tuition, and any applicable earmarked fees for the program.

   Tutition and Fees are calculated conservatively, using projected 2008 in-state tuition rates and factoring a 5 % annual tuition rate increase.

2. Please identify the source(s) of the institutional reallocations, and grant matching requirements if applicable.

   The amount is derived from reallocation of existing resources including technology access fees and indirect costs collected on grants and contracts. Additionally, funds allocated to Gas in the Chemistry DA program will be reallocated to this program. As external funding is obtained, institutional support will be reduced accordingly.

3. Please provide the source(s) of the Federal Grant including the granting department and CFDA number.

4. Please provide the name of the organization(s) or individual(s) providing grant(s) or gift(s).

5. Please provide information regarding other sources of the funding.

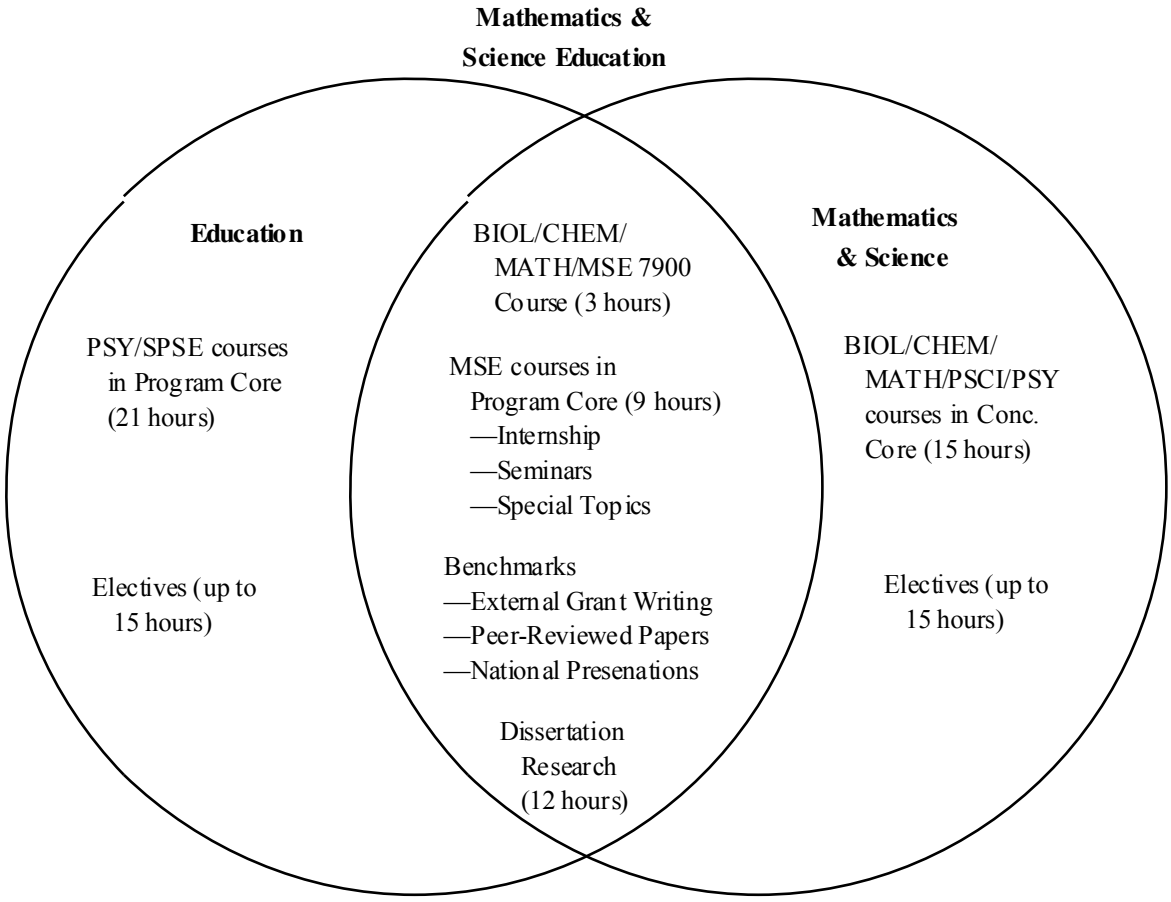
NOTES FOR EXPENSES:

Graduate Coordinator has six credit hours reassigned each semester, in addition to a $6,000 stipend in the summer.
Travel costs are included to provide for faculty, student, and visiting speakers' travel in support of the program.
Other one-time expenses include $10,000 for start-up funds for a new faculty in year-two.
Other recurring expenses include funds for print and online journal subscriptions and database subscriptions.

Appendices

Appendix 1 – Structure of the MSE Curriculum

Successful mathematics and science educators are required to have content mastery of mathematics and/or science, have mastery of educational theories, research methodologies, and best practices; and have substantial experiences with discipline-based educational research (DBER) at the interface between the fields of mathematics or science and education. The diagram below shows how the curriculum in the proposed Ph.D. will guarantee that students reach expert-level status in each of these three areas.



Mathematics & Science: Students in each concentration will take 15 hours of mathematics or science content courses. For the Biological Education, the Chemical Education, and the Mathematics Education concentrations, students will focus on developing a broad but strong content knowledge in the one content area. When these candidates graduate and are hired to teach in their content area (biology, chemistry, or mathematics), it is very likely that they will be asked to teach introductory-level courses. Teaching these courses requires the educator to have a broad but strong content knowledge of the entire field as a whole. For some candidates (i.e., those enrolled in the Interdisciplinary Science Education concentration), it will make more sense to have a broad but strong content knowledge of mathematics and the sciences as a whole. This concentration allows these students to take courses in all three areas (biology and life science,

chemistry and physical science, and mathematics). If the D.A. in Chemistry is any indication, most of the restricted elective courses taken by these students will be in the mathematics and science content areas.

Education: Students in this program will take 21 hours of education courses to develop a strong content knowledge of education and pedagogy. These courses include learning theories, cognitive psychology, qualitative and quantitative research methods, educational research methodology, and instructional technology. These students may also opt to take additional education courses as part of their restricted electives.

Mathematics & Science Education: Students in this program will also take courses that help them develop their pedagogical content knowledge (i.e., the knowledge of teaching and learning mathematics or the sciences). These courses include a teaching internship, seminars in mathematics and science education, and special topics courses in mathematics and science education. In addition, each of them will take a Teaching and Learning course that will focus on issues related to pedagogical content knowledge in a specific field of mathematics or science.

The courses in the three areas will provide the breadth of knowledge and experiences needed by these students to complete the Ph.D. degree. Their depth of expertise will be demonstrated by their doctoral dissertation research in an area of discipline-based educational research (DBER). As part of their doctoral research, these students will be required to make substantial contributions to a grant proposal sent to an external funding agency, write and submit two peer-reviewed papers, and give two presentations at national or regional mathematics and science education conferences.

Appendix 2 - Typical Course Schedule for Students in this Program

Students in this program are expected to take courses in the program core and the concentration core and electives at the same time. Students should consider taking 'Learning Theories and the Educational Process' in the program core before enrolling in the mathematics- or science-specific teaching and learning courses in the concentration core and electives. Students should focus on taking required courses prior to choosing a major advisor and a dissertation committee since decisions regarding the concentration electives should be made in consultation with these faculty members. After completing the required courses, the student will take a written preliminary exam designed by the student's major advisor and his or her dissertation committee.

Since there are four concentrations within this program and some students will enter with graduate credit (e.g., Master's or Specialist's degrees), it is difficult to envision a single suggested schedule. In every case, the students' advisory committee, or dissertation committee if they have advanced to candidacy, will conduct an annual evaluation of their progress toward completion of degree requirements.

An example of a possible schedule for a student entering with a bachelor's degree in chemistry who chose to receive the Chemical Education concentration is shown below (courses with an [E] next to them represent courses from the restricted electives). The student is enrolled for only 6 hours because it is assumed that this student's graduate assistantship will be to teach laboratory courses. Only 12 of the 20 hours of Dissertation Research (MSE 7640) would be applied toward the program of study.

<u>Fall 1</u>

CHEM 6100	Intermediate Organic Chemistry (3)
SPSE 7170	Learning Theories and the Educational Process (3)

<u>Spring 1</u>

CHEM 6230	Intermediate Analytical Chemistry (4)
MSE 7840	Special Topics in Mathematics and Science Education (2)

<u>Summer 1</u>

CHEM 6400	Intermediate Inorganic Chemistry (3)
PSY 7190	Advanced Cognitive Psychology (3)

<u>Fall 2</u>

CHEM 7420	Advanced Topics in Inorganic Chemistry [E] (3)
PSY 7290	Psychological Statistics: Anova (3)

<u>Spring 2</u>

CHEM 6500	Intermediate Biochemistry (3)
PSY 7280	Psychological Statistics: Regression (3)

Summer 2

CHEM 7900	Teaching and Learning in Chemistry (3)
SPSE 7180	Qualitative Research Methods (3)

Fall 3

FOED 7520	Problems of Evaluation in Higher Education [E] (3)
SPSE 7220	Advanced Educational Technology (3)

Spring 3

CHEM 6300	Intermediate Physical Chemistry (3)
MSE 7820	Seminar in Mathematics and Science Education (1)
MSE 7840	Special Topics in Mathematics and Science Education (2)

Summer 3

CHEM 6870	Chemistry Research [E] (3)
SPSE 7010	Educational Research Methodology (3)

Fall 4

MSE 7800	Teaching Internship (3)
PSCI 6800	Intermediate Physical Science [E] (3)

Spring 4

MATH 6330	Algebra for Teachers [E] (3)
MSE 7640	Dissertation Research (2)
MSE 7820	Seminar in Mathematics and Science Education (1)

Summer 4

MSE 7640	Dissertation Research (6)

Fall 5

MSE 7640	Dissertation Research (6)

Spring 5

MSE 7640	Dissertation Research (6)