

The University Senate of Michigan Technological University

PROPOSAL 5-01

MS PROGRAM IN APPLIED SCIENCE EDUCATION

The Senate approves the program as described below.

Related Programs

None currently.

Rationale

The Master of Science in Applied Science Education (MS-ASE) degree is intended to be a graduate degree for in-service secondary mathematics and science teachers that promotes professional development within their disciplines and addresses their classroom and students' needs. Through their course work, these candidates must demonstrate advanced ability to integrate technological literacy and real world applications into the mathematics and science curriculum serving students in grades 7-12. This emphasis is a priority in both state and national standards for secondary mathematics and science education.

In the state of Michigan, new secondary teachers are awarded provisional certification for five years. During that five year period, teachers are required to complete either an 18-hour approved program of study or a master's degree to move from provisional certification to professional certification. Most new teachers, as they work toward their professional certification, simultaneously seek enrollment in a master's degree program in education. There are financial and career benefits of the master's degree that surpass those of just professional certification.

The development of a master's program in the Education department has been a goal from the very beginning as part of the 1995 recommendation to reorganize the Division of Education and Public Service as a Department of Education under the College of Sciences and Arts. Proposal 29-95 which was unanimously approved by the Senate at its October 11, 1995 meeting lists the following expectations:

- Formalize postbaccalaureate programs in conjunction with other departments. This can take the form of*
- a) continuing professional development course work in a non-degree program (for in-service teachers).*
 - b) course work towards a master's degree in areas in which MTU has recognized strength (for in-service teachers).*
 - c) formalizing master's degrees in areas of recognized strengths which involve teacher certification.*

In April of 2000, the International Technology Education Association published new educational standards for technological literacy in the pre-college curriculum. The state of Michigan was one of those who participated in the development of these standards and it is anticipated that a set of standards for K-12 technology education will soon be developed as part of the Michigan Curricular Frameworks (the state-level standards for K-12 education). Most current pre-college teachers are ill-equipped to implement the technology standards into the curriculum when they are finalized. The emphasis of the MS-ASE program will greatly assist teachers in their quest to include technology standards in their classrooms. Many of the current math and science standards in the Frameworks call on teachers to show applications of theory through practical examples. The course work included in this master's program will enable teachers to include such applications in their math and science courses.

The nearest university offering master's degree programs for secondary mathematics and science teachers is Northern Michigan University (NMU). NMU has three such programs: 1) a Master of Arts in

Education for secondary teachers in 9 major disciplines, 2) a Master of Science degree in Enhanced Mathematics/Science Education, and 3) a Master of Science degree in Mathematics Education. The design of the proposed MS-ASE degree is different from the master's degree programs offered at NMU in that it will have a very applied emphasis, drawing upon the diverse expertise of MTU engineering faculty as well as other faculty who are well versed in applications of mathematics and science.

It is anticipated that this master's degree will be attractive to secondary mathematics and science teachers both locally and regionally. Whereas many local teachers have pursued degrees in education programs at NMU, the inconvenience of travel and the distance to NMU have prevented others from doing so. For those teachers, a program at their local university allows convenient access to a master's degree. In addition to a novel program, creative methods of delivering the course work will make the program attractive to teachers from a larger tri-state region. Use of distance learning, courses offered primarily over summer months, credit for approved teacher workshops, and the possibility of an off-campus internship are some of the features that will attract teachers from other parts of Michigan, as well as from Wisconsin and Minnesota.

Both our undergraduate education students and our graduate level students constitute potential groups from which graduate students for the MS-ASE program could be obtained. At the present time MTU's Department of Education has about 40 students who receive provisional teacher certification from the state of Michigan each year. Approximately 141 in-service teachers have received credit for workshops conducted at Michigan Tech for use toward the 18 credits needed for professional certification with the state of Michigan. Some of these graduate credits could also be used toward the proposed master's degree.

Within the next ten years an extraordinary number of retirements is expected among current secondary teachers (i.e., the "baby boomers" are retiring). As new people enter the teaching ranks to fill these vacancies, there will be great need for graduate level courses and programs in education in order for these people to move from provisional to professional certification status.

It is anticipated that the MS in Applied Science Education degree will promote stronger regional relationships between MTU and secondary mathematics and science teachers. These stronger ties will enhance MTU undergraduate student recruitment and alumni numbers.

Alignment with MTU's Strategic Plan

The proposed program aligns well with several goals and objectives of the recently adopted MTU strategic plan. The specific goals and objectives that this new program supports are:

Goal #1 Provide an outstanding and relevant learning environment, consistent with a national university of choice.

Strategy 1.3.2. (College of Sciences and Arts): Provide a model secondary teacher education program.

Goal #2 Expand our scholarship and research activities, sustaining successful existing programs while pursuing new endeavors in carefully targeted areas.

Objective 2.2 Increase the number of faculty actively engaged in research and graduate education.

Goal #3 Identify the best size and blend for our educational programs, which have a diverse student body, faculty, and staff.

Objective 3.2 Aggressively support and implement strategies to increase the diversity of our student body.

Objective 3.3 Manage and optimize enrollments within disciplines, schools and colleges for the benefit of all of our stakeholders.

Objective 3.4 Pursue aggressive targeted marketing for programs with potential and need.

Objective 3.5 As demand increases, obtain substantial additional resources to support programs important to the economic development of Michigan.

Goal #6 Support economic development, public sector out reach, and distance education appropriate for a technological university.

Administrative Structure

The administration of the program will follow the general procedure as outlined in MTU's Graduate School Bulletin. More specifically, the MS-ASE degree program will be administered by a Coordinating Committee comprised of 1) the chair of the Department of Education; 2) a representative from each participating unit or program on campus; and 3) one faculty member who holds either a tenure-track or adjunct appointment in the Department of Education who will be appointed by the chair of the Department of Education. The chair of Education will head this Coordinating Committee. By definition, a participating unit is one that has 1) developed a 12 credit block of graduate level courses that feature applications to science education from their field of study that are appropriate for inclusion at one or more grade levels of a secondary science program and 2) is willing to arrange a 3 - 6 credit industry or research internship for students in their specialty. The graduate level courses must be approved by the Coordinating Committee of the MS-ASE program and be taught by graduate faculty members in the participating unit. Each student will have an advisor in education and an advisor from his/her participating unit.

Students electing the MS-ASE degree are expected to have a baccalaureate degree and secondary teacher certification in science or mathematics and at least one year of teaching experience. The Coordinating Committee will review applications to admit students into the program.

Once the MS-ASE student has been admitted into the program, s/he will establish an individual degree program in consultation with his/her education and unit advisor. The chair of the Department of Education and the chair/director of the other participating unit will approve each individual degree program before the M-4 form is submitted to the Graduate School.

Grades -- All grades must be B (3.0 on a 4.0 scale) or better in the required education and required applied science or engineering core courses. The student must maintain a cumulative grade point average of 3.0 or better.

Time Limit -- All work required for the MS-ASE degree must be completed within five calendar years of the first enrollment in the degree program. It is expected, however, that most students will complete the requirements in three years of part-time work.

Advisors -- Students enrolled in the program will be required to have advisors in both Education and in the participating unit. Initially the advisors may be the graduate coordinators or chairs of the two departments, but as soon as possible, permanent advisors must be chosen. The advisors will primarily work to establish a reasonable schedule for completion of program requirements and will evaluate the suitability of elective science, math, or engineering credits that the student has already completed or plans to complete. The faculty advisor from the Department of Education will oversee completion of the required research project/report while the faculty advisor from the participating unit will assist the students in identifying appropriate research or industry internships and will evaluate the resulting internship paper.

Advisory Committee -- the advisory committee is nominated by the chair of the Department of Education, usually in consultation with the student's education advisor, and approved by the Dean of the Graduate School. At least three of the four examiners must be members of the graduate faculty and one of the graduate faculty must be from outside the Education department.

Engineering - A Model Program

Engineering, which involves the application of math and science in the solution of real-world problems, serves as the model option for this degree proposal. Many people, including pre-college teachers, simply do not understand what engineers do. There have been numerous requests from teachers over the past several years for Michigan Tech to offer courses that would introduce engineering to teachers so that they can offer better advice to their young students. The course work included in this model option would enable teachers to gain a real appreciation for the engineering profession while at the same time providing them with the opportunity for professional development through an advanced degree.

The Department of Engineering Fundamentals in cooperation with the Department of Education has provided the leadership for the development of this Master's degree program. Hence the College of Engineering will be the first participating unit in the MS-ASE program. The three 4-credit courses which are being developed by the Chair of the Engineering Fundamentals department and faculty within the College of Engineering will serve as a model for the remainder of this proposal.

It is anticipated that other departments or programs containing an applied emphasis (e.g., applied ecology, geology, physics, computer science, mathematics, applied molecular biology and biotechnology, etc) will develop courses from their own discipline that would replace the engineering course work and the industry/research internship shown below in the model curriculum design. Programs other than engineering may wish to require a minimum of 3 credits under the "Elective Education and/or Science Courses" in an area other than the applied life sciences to round out student exposure to a variety of applied science and engineering fields.

Model Curriculum Design in cooperation with the College of Engineering

This is a 32-credit report option (Plan B) master's degree program. It follows the requirements outlined in the Graduate School Bulletin. Students in the program will be required to have an advisor from the Department of Education as well as from the College of Engineering at Michigan Tech. The administration follows according to the administrative structure outlined before. Note: Up to 12 credits of 3000-4000 level courses are allowed in the MTU plan B master's program.

In the Education department there are currently four faculty who are graduate faculty members and ten adjunct professors who are graduate faculty members. In the Department of Engineering Fundamentals there are currently three faculty who are graduate faculty members and two more faculty members anticipated in January who will be eligible for graduate faculty status.

Required Education Courses* 6 credits

ED5700	Issues and Research in Science Education	2 credits
ED5710	Connecting Science Education Research and the Michigan Science Frameworks to Practice	2 credits
ED5720	Developing Applied Materials and Methodologies for Science Education	2 credits

Required Engineering Courses** 12 credits

ENG5100	The Engineering Process	4 credits
ENG5200	Engineering Applications in the Physical Sciences	4 credits
ENG5300	Engineering Applications in the Earth Sciences	4 credits

Required Research Paper 2 credits

ED5900	Graduate Research in Education	2 credits
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Required Industry or Research Internship 3-6 credits

ENG5900	Engineering Internship for Educators	3-6 credits
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A minimum of 3 credits must be in the Applied Life Sciences.

Selections can be made from the following 3 categories (other courses could be developed by the various sciences departments at MTU):

*taught by Northern Michigan University via distance education as a sub-contract.

NMU has agreed to teach these courses at their distance education rate of \$2,000/credit

** development funded through NSF grant.

1. MTU Summer Workshops/Courses

ED 5601 Special Content Studies in Education (Educators' Science and Mathematics Institute Series (ESMIS) workshops)

Ecology of the Great Lakes Ecosystem	3 credits
Investigating Biology, Chemistry, and Biochemistry	3 credits
Exploring Mathematics and Engineering	3 credits
Space and Planetary Sciences	3 credits
Ecology of Isle Royale	3 credits
Using Scientific Knowledge in Life Sciences	3 credits
Using Scientific Knowledge in Physical Sciences	3 credits
The Geology of Utah	3 credits

ED 5602 Special Applications in Education (ESMIS Follow-up Labs)

Ecology of the Great Lakes Ecosystem Lab	1 credit
Exploring Mathematics and Engineering Lab	1 credit
Investigating Biology, Chemistry, and Biochemistry Lab	1 credit
Space and Planetary Sciences Lab	1 credit
Ecology of Isle Royale Lab	1 credit
Using Scientific Knowledge in Life Sciences Lab	1 credit
Using Scientific Knowledge in Physical Sciences Lab	1 credit
Geology of Utah Lab	1 credit

ED 5603 Special Topics in Education (Mining Grant workshops)

Earth Science Principles and Applications	2 credits
Earth Science Principles and Applications Lab	2 credits

2. Similar electives from applied science courses offered by the Seaborg Center at NMU.

3. Other graduate level mathematics, science, or engineering courses offered at MTU.

New Course Descriptions

Three of the seven new courses required for this program will be developed and initially delivered by Northern Michigan University via distance education by sub contract. These three courses will retain an MTU course number (ED5700, ED5710, ED5720) and will be administered by the Department of Education at Michigan Tech. The description for those courses along with the other new MTU courses follow.

ENG5100 The Engineering Process

This course is intended to introduce engineering to pre-college teachers by providing them with meaningful experiences that they can bring back to their classrooms. The engineering process (as opposed to the scientific process) will be outlined as will some of the "non-technical" aspects important in engineering. Students will be required to complete a design project that meets certain criteria. During the fall semester after participation in the summer course, students will also be required to write a paper demonstrating how they implemented what they have learned in their pre-college classrooms.

ENG5200 Engineering Applications in the Physical Sciences

Students will complete hands-on explorations in engineering disciplines related to the physical sciences (Electrical, Mechanical, Metallurgical, Civil, Biomedical, Computer, and Chemical Engineering disciplines). Students will explore how math and science are applied in these disciplines and will work on projects suitable for inclusion in their pre-college classes. Review of math and science principles will be included as necessary to complete the course material. Sessions will also be conducted on the state and national science and math education standards as they apply to the physical sciences. During the fall semester after participation in the summer course, students will be required to write a paper demonstrating how they have implemented what they have learned in their pre-college classrooms. Prerequisite: ENG5100.

ENG5300 Engineering Applications in the Earth Sciences

Students will complete hands-on explorations in engineering disciplines related to the earth sciences (Geological, Mining, Mineral Processing, Environmental, Aerospace, and Civil Engineering disciplines). Students will explore how math and science are applied in these disciplines and will work on projects suitable for inclusion in their pre-college classes. Review of math and science principles will be included as necessary to complete the course material. Sessions will also be conducted on the state and national science and math education standards as they apply to the earth sciences. During the fall semester after participation in the summer course, students will be required to write a paper demonstrating how they have implemented what they have learned in their pre-college classrooms. Prerequisite: ENG5100.

ENG5900 Engineering Internship for Educators (3-6 credits)

Students will work in an internship position for one or two summer months in a local industry. If such an internship is not available or if there are no local engineering firms near the student's home, students will have the option of working with an engineering professor on a research project during the summer in fulfillment of this requirement. Students will be required to write a report at the end of their internship outlining their duties as well as how they will apply what they have learned during their internship experience to their classroom teaching. The internship will be approved by the student's engineering advisor prior to its start. Prerequisite: ENG5100.

ED5700 Issues and Research in Science Education

The study in depth of issues and research in science education including curricular standards, models, and designs for science education as well as modes of assessing student performance in science education using the Michigan Science and Mathematics Content Standards and the Michigan Teaching and Learning Standards. The course will include the changing models for understanding cognition and learning as related to science education, e.g., contextualized/distributed cognition and learning. Prerequisite: First unit of the applied science core, e.g. ENG5100 in the model program.

ED5710 Connecting Science Education Research and the Michigan Science Frameworks to Practice

The course will examine the implications of using technological applications in the physical, earth, and biological sciences as a "medium" for connecting science education research, the Michigan Mathematics and Science Frameworks, and the teaching of the sciences in secondary education, especially for evaluating and designing curricular materials and resources for science education. Prerequisite: ED5700.

ED5720 Developing Applied Materials and Methodologies for Science Education

The student will be expected to design and develop materials and methodologies for using technological concepts and processes in the classrooms and for demonstrating the student's understanding of technological concepts and processes as "mediums" for teaching the sciences, particularly with the focus on applied materials and methodologies (e.g., developing computer software programs) for advancing the student's achievement in the physical, earth, and biological sciences in accord with the Michigan Science and Mathematics Education Standards. Prerequisite: ED5700 and a second unit of the applied science core, e.g. ENG5200 or ENG5300 in the model program.

ED5900 Graduate Research in Education (1-6 credits)

Students will conduct a research project/report as a capstone to an approved plan of study. The student should present a project plan to their education advisor for approval, conduct whatever work is necessary for the project, prepare a final report at the conclusion of the project, and defend the project/report in an oral presentation. Prerequisite: ED5700.

Projected Enrollment

Funds from the NSF grant will cover 20 people in the engineering option in the first year and 20 additional in the second year. We anticipate that these slots will be filled in each of the two summers that courses are offered. As other options are approved, we anticipate a steady-state enrollment of 30-40 students.

Scheduling Plans

The required courses of the applied science or engineering core for this program will be offered as two-week intensive institutes during the summer months. The required distance education courses will initially be offered by NMU over the academic year. It is expected that a conscientious student could finish this master's degree program in three years.

Tentative Course Schedule

Summer 2001

August-ENG5100*

Fall 2001

ED5700*

Spring 2002

ED5710*

Summer 2002

June - ENG5100*

June - ENG5200*
August - ENG5300*

Fall 2002
ED5700*
ED5720*

Spring 2003
ED5710*

Summer 2003
June - ENG5100
June - ENG5300
August - ENG5200

*Funding for development and delivery of these course offerings is covered by the grant.

Elective Education and/or Science Education Courses

Michigan Tech has been offering summer workshops for pre-college teachers for the past several years in support of the professional development of math and science teachers. These workshops have been supported by various granting agencies and focus on improving pre-college math and science instruction. Topics from some recent workshops include mathematics, engineering, space, ecology, biology, chemistry, and biochemistry. Michigan Tech engineering, math, and science faculty who teach these workshops along with teachers from across Michigan and the upper midwest who participate in them agree that the workshops have been successful. The attributes of these workshops, that have been positively rated by all concerned, are their high academic caliber and the attention paid to helping teachers provide new and meaningful ways for teaching scientific concepts. The existing summer institute series for teachers is highly regarded because teaching and research faculty in engineering, math, and science not only present much of their research efforts but provide this information in a way that teachers can take and apply in their own classrooms. The assessment of these workshops is clear - teachers learn not only more about engineering and other scientific disciplines but they learn effective ways to teach these concepts to their students.

In the summer of 1998, Michigan Tech offered the Educators Ecology Institute in which 20 Upper Peninsula of Michigan teachers participated. This intensive one week Institute was designed as a pilot course that led to the development of the Educators' Science and Mathematics Institute Series (ESMIS) for teachers. Four ESMIS Institutes were implemented during the spring/summer of 1999:

- Ecology of the Great Lakes Ecosystem
- Investigating Our World with Biology, Chemistry, and Biochemistry
- Exploring Mathematics and Engineering
- Space and Planetary Sciences

Each of these ESMIS institutes was designed to draw on three main resources:

- the *expertise* of Michigan Tech faculty in providing innovative methods and applications that participating pre-college teachers could take back to their own classrooms (see appendix for list of faculty who taught in the ESMIS institutes),
- the *experience* and *insight* of participants who bring a wealth of knowledge and creativity to share with presenters and colleagues alike, and
- supporting *reference materials* and *samples* of award-winning teaching units that meet the Michigan standards for math and science education.

The elective courses for the proposed master's degree program will include summer workshops that we have offered (ESMIS) as well as those that we plan to offer in the future (e.g., the new NSF earth sciences

teacher workshops that have just been funded). Criteria that will be used to determine whether workshop credit is applicable toward this requirement include the following:

- The number of hours spent on task in the workshop are appropriate to the semester credits being granted.
- A syllabus describing the mathematics, engineering, and/or science applications of the workshop can be provided.
- The topics of the workshop line up with secondary state mathematics or science standards.
- A graded written paper or project focusing on the teaching of applications to pre-college students was a part of the workshop.
- The lead instructor of the workshop is a member of the graduate faculty at either NMU or MTU.

Other courses that could be applied to this category will include offerings from the Seaborg Center at NMU, transfer credit deemed appropriate by the student's education advisor, and graduate courses in mathematics, science and engineering.

Program Costs and Sustainability

A grant from the National Science Foundation has been acquired to pay for the cost of developing the course work and the administrative structure that are necessary components of the engineering model of the program. Since the core applied science courses for this program will be offered during the summer months as institutes, we have an adequate mechanism in place for assuring sustainability. By the summer institutes model, institutes are either supported by outside funding agencies (e.g., ESMIS) or they are self-supporting (e.g., summer institute in Humanities). For the first three years of the program, the engineering institutes will be fully funded through the NSF grant. For other core courses or for the engineering core after the grant period, if enough students are willing to enroll in the institutes, they will be offered during the summer months, with faculty receiving extra compensation according to a prescribed formula for teaching them. If students are not willing to pay to enroll in these institutes, then they will not be offered. Due to the large number of retiring teachers who will need to be replaced over the next ten years, we expect the demand for such a degree program to be great as the new teachers move from their provisional certification to professional certification.

The three Education courses to be offered via distance education should also be self-sustaining after the initial development period. These courses will be offered through a sub-contract with NMU during the period of the NSF grant. Since they will be offered with MTU course numbers, they will be administered through the Extended University Programs office. The policies and fee structures that are currently in place with Extended University Programs were developed such that all courses offered via distance education at Michigan Tech must be self-supporting or they will not be offered.

At the end of the NSF grant period, we will assess whether or not to continue our sub-contract with NMU for delivery of the education courses. If the faculty resources in the Department of Education are sufficient to offer these courses through MTU faculty at that time, then the instructional responsibility will shift to MTU. If, however, it is deemed that the Department of Education resources are not sufficient to deliver these courses, we will continue our sub-contract with NMU with Extended University Programs administering the courses and establishing the fee structures. Officials at NMU have indicated that they would be willing to teach these MTU courses on a sub-contract basis indefinitely if necessary. NMU has had and continues to have similar sub-contracting relationships with other universities in the state.

Clerical and Supplies/ Services

The Department of Education has one full-time department coordinator and a secretary who is full-time during the academic year and can work on an "as needed" basis up to 9 hours per week during the summer months. In addition the department typically employs two or three work study students. It is expected that the clerical and secretarial tasks of this program can be handled by these people. Advising of students will be done by the graduate faculty members and the adjunct graduate faculty members of the Education department and by the graduate faculty members of the Engineering Fundamentals department.

The Department of Education expects that a graduate program will enhance research and funding activities and that overhead monies from the grants will help offset the costs of additional supplies and services. Over the past couple years, the Department of Education has seen a considerable rise in grant funding and the outlook for the future is good.

Description of Available/Needed Equipment

No new equipment will be required to implement the model option of this program. Other units who plan to participate will have to assess their need at the time of planned participation.

Faculty Resumes

The faculty in the Department of Education and in the Engineering Fundamentals department at Michigan Tech have been instrumental in the development of this proposal and unanimously endorse it. The primary people involved in the development of this proposal have been the chairs of the two departments; however, input has been sought from all of the faculty in the respective units. Administrators and faculty from Northern Michigan University have also participated extensively in the design of this program. In particular, faculty from NMU's Education department were instrumental in designing the content of the required education courses and will be developing these courses as a part of their sub-contract role on the NSF grant. In the long term, faculty from MTU's Department of Education will likely be teaching the required education courses. It is likely that the required engineering courses will be team-taught by faculty from Engineering Fundamentals as well as by faculty from other departments in the College of Engineering.

Internal Status of Proposal

Planned Implementation Date

We will begin admitting students into the program as soon as final approval is obtained from the Board of Control.

Library and other Learning Resources

It is anticipated that library resources for this graduate program will initially not be great. Since the focus of the graduate program is applications in science education, many of the materials used will be journals in other fields such as engineering, biology, mathematics, and so on. The Curriculum Committee in the Education department is currently reviewing its library holdings to determine whether additional books should be ordered. A representative of the library has indicated that they will work with the members of the Education Department's Curriculum Committee in assessing our library holdings and in helping decide what is needed for this master's degree program. The Department of Education has an annual budget of about \$1,300 for library acquisitions and \$3,000 in one-time grant monies that could be used for this purpose. As the program grows, additional journals may be needed.

Space

No additional space is required for this program.

Accreditation Requirements

The state Department of Education only accredits programs where endorsements are provided. Since we are not proposing to offer new teaching endorsements with this Masters Degree program, it will not be necessary to seek accreditation.

The following items are on reserve at the J. R. Van Pelt Library

Appendix

1. Michigan Tech Faculty who taught in the Educators' Science and Mathematics Institute Series (ESMIS)
2. a) Curriculum Vitae of Core Faculty

b) Engineering faculty who have expressed an interest to develop and/or teach sessions for intensive courses and/or would be willing to serve as "engineering advisors". 3. Appropriate administrative endorsement

a) Deans of the College of Sciences and Arts and Engineering

Adopted by Senate: January 17, 2001

Approved by Administration: February 8, 2001