The University Senate of Michigan Technological University

Proposal 13-18

(Voting Units: Academic)

"A Proposal for a New Master of Science Degree in Statistics"

(Department of Mathematical Sciences)

Introduction The Department of Mathematical Sciences currently offers an M.S. degree in Mathematical Sciences that can be completed with one of four focus areas: Computational and Applied Mathematics, Discrete Mathematics, Pure Mathematics, and Statistics. We propose to spin off the Statistics focus area to a stand-alone degree program.

1. **Date submitted:** October 11, 2017.
2. **Contact:** Mark S. Gockenbach, Professor and Chair, Department of Mathematical Sciences (msgocken@mtu.edu, 487-2068).
3. **Interdisciplinary support:** Not applicable.
4. **General description and characteristics of program:** There is no accrediting agency for degree programs in Statistics. However, the American Statistical Association organized a working group that recently published the "Report of the ASA Workgroup on Master's Degrees" (November 2012[1]). This report made the following recommendations:

   (a) Graduates should have a solid foundation in statistical theory and methods.

   (b) Programming skills are critical and should be infused throughout the graduate student experience.

   (c) Communication skills are critical and should be developed and practiced throughout graduate programs.

   (d) Collaboration, teamwork, and leadership development should be part of graduate education.

   (e) Students should encounter non-routine, real problems throughout their graduate education.

   (f) Internships, co-ops or other significant immersive work experiences should be integrated into graduate education.

   (g) Programs should be encouraged to periodically survey recent graduates and employers of their recent graduates as a means of evaluating the success of their programs and to examine if other programmatic changes are warranted.

   The first five recommendations imply desirable learning goals and outcomes. We have designed the proposed degree program so that students will achieve the corresponding outcomes, as follows.

   (a) **Graduates can choose a statistical method that is appropriate for a given problem, can justify the choice theoretically, can apply the method, and can draw appropriate conclusions.** All students must take a two-semester sequence on

[1] http://magazine.amstat.org/wp-content/uploads/2013an/masterworkgroup.pdf

Mathematical Statistics and courses on Linear Models and Multivariate Statistics. These courses cover the basic theory of statistics. They must also take at least two graduate electives in statistics (most of which address applied statistics). These requirements are built on top of the expected prerequisites for the program, which include introductory statistics, probability, linear regression, and the design of experiments.

(b) **Graduates can use popular statistical software to solve realistic problems.** Students admitted to this program are expected to have some knowledge of statistical software, and all courses (with the exception of Mathematical Statistics) involve significant use of statistical software for course homework and projects. In addition, students can choose the elective course Computational Statistics to develop a stronger background in computing.

(c) **Graduates can summarize and explain the results of statistical analyses orally and in writing.** The required course on Multivariate Statistics assigns a significant project with an oral and written report. Several of the elective courses have similar requirements. For instance, Predictive Modeling requires two in-class presentations and a written report. Computational Statistics requires one in-class presentation and a final written report. Statistical Consulting gives students experience in communicating with clients.

(d) **Graduates have experience working in teams.** The project in Multivariate Statistics is a team project, allowing students the opportunity to develop collaboration and teamwork skills. The elective course on Statistical Consulting also requires a team project. Many of the courses involve occasional group work.

(e) **Graduates know how to work with real data. They can clean the data, deal with missing data values, and generally appreciate the complexities of handling real-world data.** Most of the required courses and electives (again, excluding the Mathematical Statistics sequence) assign problems or projects involving real data. Several of the courses require significant projects.

We have not included an internship requirement in the design of the degree. However, students are encouraged to pursue internship opportunities in the summer.

5. Rationale:

(a) We are creating the stand-alone degree for two reasons:

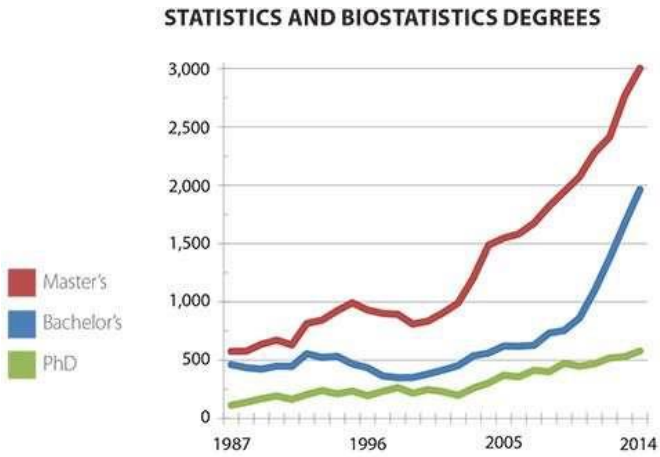
i. To give more visibility to our program (students interested in studying Statistics may not even notice a degree in "Mathematical Sciences with a focus area in Statistics").

ii. To remove a possible disadvantage for our graduates (employers who want to hire a Statistician might be suspicious of a candidate with a degree in Mathematical Sciences).

(b) "Statistician" is number seven on the Bureau of Labor Statistics (BLS) list of fastest growing occupations, with a predicted increase of 33% in positions over the period 2016–2026. (The average growth for all occupations is predicted to be about 7%.) According to the BLS, "[s]tatisticians typically need at least a master's degree in statistics, mathematics, or another quantitative field. However, a bachelor's degree is sufficient for some entry-level jobs."

Across the United States, the number of statistics degrees awarded has been steadily increasing, as shown in the following chart[2]:

[2]Taken from *Statistics Degrees Continue Strong Growth*, Amstat News (American Statistical Association), 1 October 2015, http://magazine.amstat.org/blog/2015/10/01/statistics-degrees-continue-strong-growth/



As these data show, there is strong demand for advanced degrees in Statistics, both from students and the job market. The proposed degree program, which already exists under a different name, has a record of preparing students for the job market and for PhD programs.

6. Related programs:

(a) At Michigan Tech:

i. M.S. in Data Science (interdisciplinary program). This is a broader curriculum, including work in computer science and application areas in addition to statistics. Depending on the individual student's choice of electives, 10% to 50% of the coursework in the Data Science curriculum consists of statistics courses.

ii. M.S. in Applied Statistics (new degree proposal; currently under review). This curriculum is more applied and is not intended for students intending to continue for a PhD in Statistics. Many graduate electives in Statistics are available to both programs.

(b) At other institutions: Numerous institutions in the region and around the country offer a master's degree in Statistics. Here are three regional examples:

i. Michigan State University, M.S. in Statistics. This program requires 30 credits of coursework, with four required courses. Three of these required courses are very similar to our required courses on Mathematical Statistics (I and II) and Linear Models.

ii. Western Michigan University, M.S. in Statistics. This program requires 32 credits of coursework, with five required courses. Three of these courses are similar to ours (two courses on statistical theory and one on linear models), and a fourth (Design of Experiments) is a prerequisite for our program. (Students admitted to our program who have not previously taken Design of Experiments are directed by their advisor to take the course as an elective.)

iii. University of Wisconsin, M.S. in Statistics. Five courses are required, including two semesters of theory (similar to our required courses Mathematical Statistics I and II) and two semesters on regression and the analysis of variance (which have significant overlap with our required courses on Linear Models and Multivariate Statistics). The UW degree requires a course on statistical consulting, which is an elective for our program.

7. **Projected enrollment:** We expect a combined enrollment of about 15 students in the M.S. and PhD programs.

8. **Scheduling plans:** Regular.

9. **Curriculum design:** The M.S. in Statistics will be offered under the Thesis Option, Report Option, and Coursework (with exam) Option. Here are the course requirements:

   (a) Complete the following required courses:

MA5711	Mathematical Statistics I	Fall
MA5712	Mathematical Statistics II	Spring
MA5731	Linear Models	Fall
MA5741	Multivariate Statistics	Spring

   (b) Complete at least two electives, chosen from among the following:

MA5702	Statistical Consulting	Spring
MA5730	Nonparametric Statistics	Fall (alternate years)
MA5732	Generalized Linear Models	Spring (alternate years)
MA5750	Statistical Genetics	Spring (alternate years)
MA5761	Computational Statistics	Fall
MA5770	Bayesian Statistics	Fall (alternate years)
MA5781	Time Series Analysis and Forecasting	Spring
MA5790	Predictive Modeling	Fall
MA5791	Categorical Data Analysis	Spring (alternate years)
MA6700	Advanced Topics in Statistics	Spring (alternate years)
MA6701	Probability	Fall (alternate years)

   Additional coursework, as needed (three credits for the Thesis Option, six credits for the Report Option, and 12 credits for the Coursework Option, can be chosen from the above list or from 4000 and 5000-level courses in mathematics. Note that coursework on computational mathematics, especially numerical linear algebra and optimization, would be advantageous for students who want more emphasis on computational statistics.

Accelerated M.S. option The accelerated M.S. is open only to Michigan Tech undergraduates majoring in Statistics. Students must be admitted to the acelerated M.S. degree before graduation, and ideally before the beginning of their senior year. The following courses will count toward both the B.S. and M.S. degrees:

MA4710	Regression Analysis	Fall
MA4720	Design and Analysis of Experiments	Spring

Recommended electives If possible, accelerated M.S. students should take the following electives while undergraduates:

MA4330	Linear Algebra	Fall
MA4450	Real Analysis	Fall

These additional mathematics courses will help prepare students for the graduate sequence in Mathematical Statistics (MA5711, MA5712) and the required courses on Linear Models (MA5731) and Multivariate Statistics (MA5741). They are especially recommended for students who may wish to pursue a PhD in Statistics following the accelerated M.S.

10. **New course descriptions:** None. The schedule of offered courses is being modified to meet the needs of the accelerated master's degree option.

11. **Model schedule:**

Year 1:

Fall: MA5711, MA5731, plus an elective chosen from the following:

- MA3740 Statistical Programming and Analysis
- MA4710 Regression Analysis
- MA5761 Computational Statistics
- MA5730 Nonparametric Statistics (offered in odd years)
- MA5770 Bayesian Statistics (offered in even years)
- MA5790 Predictive Modeling

Spring: MA5712, MA5741, plus an elective chosen from the following:

- MA4720 Design & Analysis of Experiments
- MA5702 Statistical Consulting
- MA5750 Statistical Genetics (offered in odd years)
- MA5732 Generalized Linear Models (offered in even years)
- MA5781 Time Series Analysis and Forecasting
- MA5791 Categorial Data Analysis (offered in even years)

Year 2:

Fall: Further electives and/or thesis research.

Spring: Further electives and/or thesis research.

Note that most students pursuing this degree are supported on teaching or research assistantships and complete the degree in two academic years.

Model schedule for accelerated M.S. The following schedule completes the B.S. and M.S. in Statistics in five years.

Year 1

Fall: (14 credits)

- UN1015 (Composition)
- CH1150 (University Chemistry I)
- CH1151 (University Chemistry Lab I)
- MA1910 (Exploring Symmetry Groups) (free elective credit)
- MA1160 (Calculus with Technology I)

Spring: (16 credits)

- UN1025 (Global Issues)
- GE 2000 (Understanding the Earth)
- MA2160 (Calculus with Technology II)
- MA2710 (Introduction to Statistical Analysis)
- General Education Critical and Creative Thinking Core course

Year 2

Fall: (16 credits)

- MA3160 (Multivariable Calculus with Technology)

- MA3740 (Statistical Programming and Analysis)
- General Education Social Responsibility and Ethical Reasoning Core course
- HASS Communication/Composition course (3 credits)
- Free electives (3 credits)

Spring: (16 credits)

- MA2330 (Introduction to Linear Algebra)
- MA3750 (Introduction to SAS Programming)
- HASS Humanities and Fine Arts course (3 credits)
- Free electives (6 credits)
- Approved cognate course (3 credits)

Year 3

Fall: (16 credits)

- MA3720 (Probability)
- MA4710 (Regression Analysis)
- HASS Social and Behavioral Sciences course (3 credits)
- Free electives (4 credits)
- Approved cognate course (3 credits)

Spring: (16 credits)

- MA3450 (Introduction to Real Analysis)
- MA4720 (Design & Analysis of Experiments)
- HASS course (3 credits)
- Free electives (4 credits)
- Approved cognate course (3 credits)

Year 4

Fall: (16 credits)

- MA4760 (Mathematical Statistics I)
- MA4790 (Predictive Modeling)
- MA4945 (History of Mathematics)
- Free electives (7 credits)

Spring: (14 credits)

- MA4770 (Mathematical Statistics II)
- MA4780 (Time Series Analysis and Forecastin)
- Free electives (8 credits)

Year 5:

Fall: MA5711, MA5731, plus two electives chosen from the following:

- MA5761 Computational Statistics
- MA5730 Nonparametric Statistics (offered in odd years)
- MA5770 Bayesian Statistics (offered in even years)

Spring: MA5712, MA5741, plus two electives chosen from the following:

- MA5702 Statistical Consulting
- MA5750 Statistical Genetics (offered in odd years)
- MA5732 Generalized Linear Models (offered in even years)
- MA5791 Categorial Data Analysis (offered in even years)

Note that this schedule assumes that students will take four graduate courses per semester during year 5. To reduce this load, students can opt to take one or two graduate courses in year 4 under the senior rule (if practical—this will work for the schedule of some students, and not for others).

12. **Library and other learning resources needed:** None; current resources are adequate.
13. **Faculty resumes:** www.math.mtu.edu/~msgocken/StatisticsCVs.
14. **Description of available/needed equipment:** The Tech standard computer lab image includes the statistical software packages R and SAS, and also standard office productivity software. This is sufficient for students in the M.S. in Statistics. No other equipment is needed.
15. **Program costs, years 1, 2, and 3:** No additional costs are expected. This degree is already being offered under the title "M.S. in Mathematical Sciences." There is no intent to significantly increase enrollment, and therefore no increased costs are expected.
16. **Space:** No new space is needed.
17. **Policies, regulations, and rules:** Admission to the degree follows usual departmental and graduate school policies.
18. **Accreditation requirements:** Not applicable.
19. **Planned implementation date:** Fall 2018

APPENDIX A

Department of Mathematical Sciences Information for Financial Evaluation

Proposed Master of Science degree in Applied Statistics

Proposed Master of Science degree in Statistics

Proposed PhD degree in Applied Statistics

1. Introduction

The Department of Mathematical Sciences currently offers an MS and PhD in Mathematical Sciences that can be completed with one of four focus areas: Computational and Applied Mathematics, Discrete Mathematics, Pure Mathematics, and Statistics. We propose to spin off the Statistics focus area to a stand-alone MS in Statistics, and PhD in statistics. The financial evaluation focuses on the MS in applied statistics which is an additional program, with the MS in Statistics and PhD in Statistics being existing programs continuing under different names.

2. Relation to university Strategic Plan This proposal supports Goal 2 (A distinctive and rigorous action-based learning experience grounded in science, engineering, technology, sustainability, business, and an understanding of the social and cultural contexts of our contemporary world), especially the sub-goals listed under 2.3:

a. expand Ph.D. and masters enrollments, degrees awarded, and scholarly productivity;

b. improve access via non-traditional delivery of graduate programs;

The main purpose of this proposal is to increase enrollment in master's degree programs. The proposed hybrid option (part online, part on-campus) is intended to improve access to the degree program.

3. Impact on university enrollment

(a) We plan for a steady-state enrollment of 25 students for the MS in Applied Statistics

(b) We expect the enrollment to represent new students (i.e. students who would not other- wise have enrolled in a graduate program at Michigan Tech).

(c) There is considerable evidence of an increased national demand for statistics degrees (see our original proposal for details). This appears to be uncorrelated with existing enrollment patterns at Michigan Tech.

(d) The department currently enrolls 114 BS, 9 MS, and 31 PhD students.

4. Impact on resources required by department in which the program is housed

(a) The program will require no new courses, but we expect to offer as many as four new sections of existing courses (certain courses will be offered twice per year instead of the current once per year). This equates to one tenure-track faculty line. However, the department is in the process of filling a Lecturer position in Statistics that may make it possible to cover the required sections without a new faculty line.

(b) Existing computer labs are adequate for the anticipated increased enrollment.

(c) Advising will be done by existing faculty, detracting slightly from time otherwise spent on teaching and research.

(d) The department will have to perform regular assessment of the new program, adding somewhat to faculty service loads. As with advising, this will have a small detrimental effect on faculty efforts in research and teaching.

5. Impact on resources required by other units within the university

(a) All required and most elective coursework will be delivered by the department. Students can take up to two cognate courses from other departments that count toward degree requirements. The additional enrollments should be small and spread out over various courses and departments. Therefore, this is not expected to be a significant burden on other departments.

(b) Existing library and IT resources are expected to be adequate for the additional enrollment. There may be a small additional need for Career Services (advising and employer outreach).

6. Assessment of the ability to obtain the necessary resources assuming requested funds are obtained There is no question that it is difficult to hire and retain statisticians. Nevertheless, the department has hired three tenured or tenure-track faculty in this area in the past five years and is about to fill a Lecturer position.

7. Past proposals The department created a BS in Statistics (effective Fall 2014). We proposed to increase the number of students graduating with the bachelor's degree in statistics from

2.75 per year to 10 per year. (Note: 2.75 was the average number of students graduating each year with a bachelor's degree in mathematics and concentration in statistics, before the degree in statistics was created.) This increase was to occur over five to six years. In the first three years since the degree was created, we graduated an average of four students per year, whereas we had hoped to be up to six or seven students per year by now.

The cost of the new degree program has been minimal. No new faculty were associated with the bachelor's degree in statistics.

The bachelor's degree in statistics has only slightly increased enrollment in the department (possibly by a handful of students).

8. Departmental budget contribution

(a) The Department of Mathematical Sciences General Fund base budget for FY17 was $4,282,706. In addition, internal support for graduate students (GTAs) amounted to $759,697, for a total of $5,042,403.

(b) During FY17, the department delivered 22,812 Student Credit Hours (SCH) at the undergraduate level (14,433 lower division and 8,380 upper division) and 930 SCH at the graduate level. The approximate (undiscounted) tuition revenue was $6,898,974+$4,433,020+$856,530, a total of $12,188,524.

9. How do the benefits from this program compare to other alternatives that are currently under consideration or development? The only other program being considered by the department is to offer this degree (M.S. in Applied Statistics) as an online degree. The approval of this degree will make that option possible. The department is not considering other programs at this time.