Michigan Tech

# Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

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**TO:** Richard Koubek, President

**FROM:** Jacqueline E. Huntoon, Provost & Senior Vice President for Academic Affairs Jacqueline E Huntoon

**DATE:** December 13, 2019

**SUBJECT:** Senate Proposal 2-20

Attached is Senate proposal 2-20, "Proposal for a new Bachelor of Science degree in Mathematics and Computer Science," which the Senate passed at their December 11, 2019 meeting. I have reviewed this proposal and recommend approving it.

I concur X do not concur_____ with this recommendation.

Richard Koubek, President

12/16/19
Date

Michigan Tech

*University Senate*

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|---|---|
| **DATE:** | December 12, 2019 |
| **TO:** | Richard Koubek, President |
| **FROM:** | Michael Mullins<br>University Senate President |
| **SUBJECT:** | Resolution 2-20 |
| **COPIES:** | Jacqueline E. Huntoon, Provost & Senior VP for Academic Affairs |

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At its meeting on December 11, 2019, the University Senate approved Proposal 2-20, "Proposal for a new Bachelor of Science degree in Mathematics and Computer Science". Feel free to contact me if you have any questions.

The University Senate of Michigan Technological University
Proposal 2-20

# Proposal for a new Bachelor of Science degree in Mathematics and Computer Science
# Department of Mathematical Sciences

1. **Date submitted:** 2 April 2019 (Typographical error corrected 29 August 2019). Revised, 31 October 2019.

2. **Contact:**

   - Mark S. Gockenbach, Professor and Chair, Mathematical Sciences (msgocken@mtu.edu, 487-2068).
   - Linda Ott, Professor and Chair, Computer Science (linda@mtu.edu, 487-2315).

3. **Interdisciplinary support:** This proposal is made jointly by the Departments of Mathematical Sciences and Computer Science.

4. **General description and characteristics of program:** The proposed program requires 13–14 courses (42–45 credits) in Mathematics, 11–12 courses (33–36 credits) in Computer Science, and 39 credits of university-required General Education (eight credits of General Education are covered by degree requirements in Mathematics and Computer Science). It allows 11 credits of free electives, while requiring a total of 120 credits (plus co-curricular credit). MA4900 (Mathematical Sciences Project) acts as a capstone course, requiring a significant programming project addressing advanced mathematical content.

   The learning goals of the degree are as follows:

   (a) Mathematics:
      i. Majors are familiar with the characteristics of problem formulation, balancing necessary and sufficient conditions.
      ii. Majors demonstrate the ability to solve problems in Algebra, Analysis, Combinatorics, and Statistics.
      iii. Majors demonstrate the ability to verify mathematical work by using different methods to approach the same problem.

   (b) Computer Science
      i. Majors are familiar with computer organization, data structures, and theoretical computing models.
      ii. Majors demonstrate ability to construct clear and efficient software solutions to computational problems.
      iii. Majors demonstrate ability to design computational algorithms in a way that demonstrates comprehension of the tradeoffs involved in design choices.

5. **Title of program:** Mathematics and Computer Science (B.S.)

6. **Rationale:** According to numerous sources, some of the fastest-growing jobs are in mathematics and computer science. For instance, the Bureau of Labor Statistics (BLS) has published its prediction of the 20 fastest-growing occupations for the period 2016–2026.[1] Five of these occupations require training in mathematics or computer science, or both: statistician (#7), software developer (#9), mathematician (#10), information security analyst (#16), and operations research analyst (#18). Moreover, many of the other fastest-growing occupations pay poorly, with only nine of the 20 paying at least $60,000 per year (2017 median salary). Among the high-paying occupations, the mathematics and computer science occupations rank as follows: statistician (#3), software developer (#4), mathematician (#5), information security analyst (#7), and operations research analyst (#9).

   Although the BLS does not currently recognize "data scientist" as an occupational category, and therefore does not provide any prediction about job growth in that field, other sources are predicting a large increase in the number of data scientist positions. For instance, IBM published the study *The Quant Crunch: How the Demand for Data Science Skills is Disrupting the Job Market*,[2] which predicted 364,000 new jobs openings for data scientists by 2020.

   We have designed the proposed degree to include the core coursework in both Mathematics and Computer Science, plus elective courses in these disciplines to allow for some specialization. As a result, a graduate with a degree in Mathematics and Computer Science can be prepared for many of the positions mentioned above. For someone wishing to be a mathematician in industry, there is probably no better undergraduate degree than Mathematics and Computer Science. (For example, Tom Grandine, an applied mathematician at Boeing Corporation, has said that the work of a mathematician in industry is almost always expressed in computer code.) Similarly, Mathematics and Computer Science form an excellent background for an operations research analyst, especially if the Mathematics electives are used to take additional courses in Statistics. The free electives allow additional work in a cognate discipline if desired.

   Data Science is often described as the intersection of Mathematics and Statistics, Computer Science, and domain-specific knowledge. The proposed degree in Mathematics and Computer Science will provide a strong foundation in both Mathematics and Computer Science, and the five electives (two or three each in Mathematics and Computer Science) can give the degree a considerable emphasis on Data Science. For example, a student could fulfill these electives with Regression Analysis (MA4710), Time Series Analysis and Forecasting (MA4780), Predictive Modeling (MA4790), Artificial Intelligence (CS4811), and Data Mining (CS4821). The 11 credits of free electives allow a student to obtain domain-specific knowledge in another discipline. The degree would lead naturally into Michigan Tech's M.S. in Data Science.

   If the Computer Science electives are used to take coursework in Software Engineering, such as Software Quality Assurance (CS3712), Model-Driven Software Development (CS4710), Software Processes and Management (CS4711), etc., a graduate can be well qualified for Software Engineering positions that involve significant mathematical content. Finally, the Mathematics and Computer Science degree will provide an excellent foundation for a master's degree in Statistics or Applied Statistics (assuming the elective courses in Mathematics are chosen appropriately).

7. **Related programs:**

   (a) At Michigan Tech:

      i. Michigan Tech currently offers several concentrations in Mathematics (including Discrete Mathematics and Applied and Computational Mathematics) and several in Computer Science (including Computer Science, Computer Systems, and Applications), as well as

[1] https://www.bls.gov/ooh/fastest-growing.htm.
[2] https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=IML14576USEN&

a stand-alone degree in Software Engineering. Students wishing to combine the two disciplines can complete a major in one and a minor in the other, or complete a double major.

A new degree is proposed because a minor does not provide enough training in the second discipline, while the double major is too restrictive:

- Adding a minor in Mathematical Sciences to a B.S. in Computer Science requires only two additional mathematics courses (one theory-oriented course and one 4000- level elective).
- Adding a minor in Computer Science to a B.S. in Mathematics requires an additional six CS courses. (CS1121 fulfills the programming requirement for the Mathematics degree, CS1122 is a required prerequisite, and then the minor requires five more CS courses and MA3210, which is already required by the Mathematics degree.)
- The double major in Mathematics and Computer Science requires a total of 130 credits and allows no free electives (all the free electives in one program are used to fulfill requirements in the other program).

The proposed program will be considerably stronger than the B.S. in Mathematics with a minor in Computer Science. Unlike the double major, it can be completed in eight semesters while allowing the student some freedom to explore other subjects.

(b) At other institutions (three examples):

i. The University of Illinois at Urbana-Champaign has a long-standing Mathematics and Computer Science degree. It requires 7–9 courses in Mathematics (24–30 credits) and 10–12 courses in Computer Science (35–41 credits), for a total of 19 courses and 65 credits. The proposed program requires more Mathematics (primarily by requiring three advanced electives) and a comparable amount of Computer Science.

ii. Stanford University offers an interdisciplinary degree in Mathematical and Computational Science (MCS) that draws on faculty in four departments: Computer Science, Mathematics, Management Science and Engineering, and Statistics. The degree requires a core of seven courses in Mathematics (28 credits), five courses in Computer Science (22–24 credits), two or three courses in Management Science and Engineering (7–11 credits), three courses in Statistics (11–12 credits), and one more course in Mathematics, Statistics, or Computer Science that satisfies the Writing in the Major requirement. An additional three elective courses (at least nine credits) must be chosen from any of the MCS departments.

iii. The University of Oregon offers an interdisciplinary degree in Mathematics and Computer Science that requires 11 courses in Mathematics (44 credits) and 10 courses in Computer Science (40 credits). The requirements in Computer Science seem similar to those of the proposed program; for Mathematics, Oregon requires more depth (with three two-semester sequences in Discrete Mathematics, Linear Algebra, and Numerical Analysis or Statistics) and less breadth than does our proposal.

8. **Projected capacity:** We could enroll 100 students in this program, at the cost of adding 5–7 new sections per year in Mathematical Sciences (one each of MA2330, MA3210, MA3310, MA3450, MA4900, and possibly one each of MA2710 and MA3560) and 4–5 new sections per year in Computer Science (one each of CS2321, CS3141, CS3311, CS3425, CS4321).

9. **Curriculum design:** The degree requires 42–45 credits of Mathematics, 33–36 credits of Computer Science, 39 credits of General Education (with eight of these credits double-counted with the Mathematics/Computer Science requirements), and 11 credits of free electives, for a total of 120 credits. Three credits of co-curriculars are also required, as per university rules.

- Mathematics: 13–14 courses, 42–45 credits:
  - MA1160/2160/3160: Calculus sequence
  - MA2330: Linear Algebra
  - MA2710: Introduction to Statistical Analysis
  - MA3210: Introduction to Combinatorics
  - MA3310: Introduction to Abstract Algebra
  - MA3450: Introduction to Real Analysis
  - MA3560: Mathematical Modeling with Differential Equations
  - MA4945: History of Mathematics or an approved upper division global literacy course
  - MA4xxx: Electives (2 or 3 courses) (certain 3000-level courses are also allowed: MA3202, MA3203, MA3720, MA3740, MA3924).
  - MA4900: Mathematical Sciences Project (capstone course; requires a significant programming project addressing a mathematical problem or class of problems).
- Computer Science: 11–12 courses, 33–36 credits
  - CS1121/1122: Introduction to Programming I and II
  - CS1142: Programming at HW/SW Interface
  - CS2321: Data Structures
  - CS3141: Team Software Project
  - CS3311: Formal Models of Computation
  - CS3421: Computer Organization
  - CS3425: Introduction to Database Systems
  - CS4321: Introduction to Algorithms
  - CS3xxx or CS4xxx: Electives (2–3 courses)

  Note: Five advanced MA and CS electives are required, with at least two from each discipline.
- General education: 39 credits. Eight of these required credits are covered by above courses, leaving a net of 10 courses and 31 credits, as follows:
  - Core (UN1015, UN1025, Critical & Creative Thinking course, Social Responsibility & Ethical Reasoning course)
  - HASS (four courses, as specified by university policy)
  - Two science courses, one with a lab
- Free electives: 11 credits

10. **New course descriptions:** None.

**11. Model schedule:**

Year 1

Fall: (13 credits)

- UN1015 (Composition)
- MA1910 (Exploring Symmetry Groups) (free elective credit)
- **MA1160 (Calculus with Technology I)**
- **CS1121 (Introduction to Programming I)**

Spring: (17 credits)

- UN1025 (Global Issues)
- CH1150 (University Chemistry I)
- CH1151 (University Chemistry Lab I)
- **MA2160 (Calculus with Technology II)**
- **MA2330 (Introduction to Linear Algebra)**
- **CS1122 (Introduction to Programming II)**

Year 2

Fall: (16 credits)

- **MA3160 (Multivariable Calculus with Technology)**
- **MA3210 (Introduction to Combinatorics)**
- **CS1142 (Programming at the HW/SW Interface**)
- **CS2321 (Data Structures**)
- General Education Critical and Creative Thinking Core course

Spring: (15 credits)

- **MA2710 (Introduction to Statistical Analysis)**
- **MA3560 (Math Modeling with Differential Equations)**
- **CS3425 (Introduction to Database Systems)**
- General Education Social Responsibility and Ethical Reasoning Core course
- Free electives (3 credits)

Year 3

Fall: (15 credits)

- **MA4945 (History of Mathematics) or an approved upper division global literacy course**
- **CS3311 (Formal Model of Computation)**
- **CS3421 (Computer Organization)**
- GE 2000 (Understanding the Earth)
- HASS Social and Behavioral Sciences course

Spring: (14 credits)

- **MA3450 (Introduction to Real Analysis)**
- **MA4xxx (mathematics elective)**
- **CS3141 (Team Software Project)**
- HASS Humanities and Fine Arts course
- Free electives (2 credits)

Year 4

Fall: (15 credits)

- **MA3310 (Introduction to Abstract Algebra)**
- **MA4xxx (mathematics elective)**
- **CS4321 (Introduction to Algorithms)**
- **CS3xxx or CS4xxx (computer science elective)**
- HASS Communication/Composition course

Spring: (15 credits)

- **MA4xxx (mathematics elective)** or **CS3xxx or CS4xxx (computer science elective)**
- **MA4900 (Mathematical Sciences Project)**
- **CS3xxx or CS4xxx (computer science elective)**
- HASS course
- Free electives (3 credits)

12. **Library and other learning resources needed:** None.
13. **Description of available/needed equipment:** Michigan Tech already has the necessary software licenses and computer labs. However, it is possible that additional lab space will be required when the enrollment of this new degree program reaches beyond 80.
14. **Program costs, years 1, 2, and 3:** The only anticipated program costs for the first three years are for recruiting (specifically, advertising the new program to high school teachers and counselors, and directly to students). We expect to spend about $1000–2000 per year for buying names and mailings.
15. **Accreditation requirements:** Not applicable.
16. **Planned implementation date:** Fall 2020.

# Additional information

1. **Policies, regulations, and rules:** The department chair of Mathematical Sciences will be responsible for administering the program in accordance with university policy.
2. **Scheduling plans:** Regular.
3. **Space:** No additional space required (except possibly additional computer science lab space, as noted above).
4. **Faculty resumes:** math.mtu.edu/~msgocken/MathCS_CVs
5. **Financial implications:** See below.

# Financial implications

1. **Relation to University Strategic Plan**

**(a) Relation of program to the university's educational and research goals**

This proposal directly supports our stategic plan in **Education**: *Provide a distinctive and rigorous action-based learning experience grounded in science, engineering, technology, business, sustainability, and an understanding of the social and cultural contexts of our contemporary world.* It is especially supportive of the following subgoals:

- *Promote mutual appreciation of, and collaborative opportunities across, academic disciplines.* Although housed in Mathematical Sciences, the proposed program is a joint effort with Computer Science, and required coursework is fairly evenly divided between the two departments.
- *Continually assess, review, and improve programs and develop new offerings in emerging disciplinary and interdisciplinary areas.* The proposed program is obviously interdisciplinary. Although the disciplines involved cannot be said to be emerging, it is true that the rapidly increasing demand for graduates with training in both mathematics and computer science is a recent phenomenon.
- *Expand programs in response to social and economic needs and challenges.* As described above, there is significant economic demand for individuals trained in both mathematics and computer science.

**(b) Consistency with the university's resource allocation criteria**

The university has set a goal of increasing both undergraduate and graduate enrollment (see, for example, Portrait 2045). Resources are expected to be allocated to units that contribute to increased enrollment.

**2. Impact on University Enrollment**

**(a) Projected number of students in the program**

Our goal is a steady-state enrollment of 100 students. Given recent increases in computer science enrollments across the country, this seems to be an ambitious but not unrealistic goal.

(b) **Source of new students; in particular, will the students be drawn from existing programs, or will they be students who would otherwise not have come to MTU?**

Our intent is to enroll students who would not otherwise have come to Michigan Tech, though it is possible that some of the students might otherwise have enrolled in Computer Science or Mathematics at Tech.

**(c) What is the likely correlation between demand for the new program and existing enrollment patterns at MTU?**

Computer Science is already experiencing a growth in enrollments. It is expected that demand for this program would be highly correlated with Computer Science enrollments, which have experienced at least two significant cycles (rapid growth followed by rapid decline) in past decades. If computer science, as a discipline, experiences another sharp decline in enrollments, enrollment in the proposed program may decline as well.

**(d) What is the current enrollment in the unit?**

2017–18 enrollment was 91 undergraduate students and 44 graduate students. In addition, 25 undergraduate students were enrolled in Mathematics as a secondary major.

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

- We anticipate needing one additional faculty line in Mathematical Sciences if the goal of 100 additional students is reached. This additional line would be needed to allow additional sections to be offered, as specified above.
- Additional advising time is estimated at 50 hours per year. Mathematical Sciences assigns faculty members as advisors and will need to find at least two additional faculty to act as advisors (advising activities are counted as service on the part of the faculty).
- Additional assessment time is estimated as at most 10 hours per year. Mathematics and Computer Science students will take the same core mathematics courses as students majoring in Mathematics, and the assessment can be done together for the most part. However, time will be required for obtaining assessment results from faculty in Computer Science and for reporting.

4. **Impact on resources required by other units within the university.**

- We anticipate needing at least one additional faculty line in Computer Science if the goal of 100 additional students is reached. Additional support for CS lab courses will also be needed, which could be provided by a lecturer or additional graduate teaching assistants.
- Additional advising time is estimated at 20 hours per year for Computer Science. Mathematical Sciences will be responsible for most of the student advising. However, the Department of Computer Science will assist on advising especially when the computer science courses are involved. Computer Science has a full-time undergraduate advisor.
- Additional assessment time is estimated at 8 hours per year. Mathematics and Computer Science students will take the same core computer science courses as students majoring in Computer Science, and the assessment can be done together for the most part. Some addi- tional time will be required for communicating assessment results to Mathematical Sciences.

5. **Assessment of the ability to obtain the necessary resources assuming requested funds are obtained.**

If funding allows Mathematical Sciences to fill an additional faculty line, we anticipate no particular challenges in filling the position. Recent faculty searches in mathematics have been successful. Recruiting faculty in Computer Science is somewhat more challenging, but it is still realistic to fill the anticipated line.

6. **Past proposals.**

- Last year, the department proposed a new M.S. in Applied Statistics. It was approved by the Senate in March 2018 by the State of Michigan in Summer. **Update:** As ofFall 2019, 28 students are enrolled in this program. (Note: Last year, we also proposed new M.S. and Ph.D. degrees in Statistics. However, these degrees represent a re-naming of existing programs offered under the name of Mathematical Sciences.)
- In the 2013-14 academic year, the department proposed a new B.S. in Statistics, which was officially approved in June 2014. We projected an enrollment by now of approximately 30 students. However, the current enrollment is only 11 students. Recruitment for this program in ongoing. The B.S. in Statistics has incurred few costs or other resources, and no new faculty.

  Total undergraduate enrollment in Mathematical Sciences (including double majors) was 100 in 2013-14. As of Fall 2018, it was 124.

7. **Departmental Budget contribution**

- What is the department's total general fund budget?
  - $4,485,914
- **How much tuition does the department generate?**
  - Tuition generated by Mathematical Sciences students: $2,311,444
  - Tuition generated from credit hours taught by the department: $15,793,773

  These figures are for Fall 2017, Spring 2018, and Summer 2018.

8. **How do the benefits from this program compare to other alternatives that are currently under consideration or development?**
   In terms of the potential for increased enrollment, the department considers this to be the most promising bachelor's degree that it can create at this time.