The University Senate of Michigan Technological University

Proposal 16-23

(Voting Units: Academic)

Proposal for a Bachelor of Science degree in Data Science

Proposed by: Department of Computer Science, College of Computing

1. **Date submitted:** January 25, 2023

2. **Contact:**
   a. Laura Brown, Associate Professor, Department of Computer Science
   b. Andy Duan, Chair and Professor, Department of Computer Science

3. **Interdisciplinary Programs:**

While the proposed degree program is housed in the Department of Computer Science, it requires coordination and collaboration with units across campus, in particular with the Department of Mathematical Sciences.

4. **General Description of the Program:**

The proposed B.S. in Data Science is centered on the essentials of data science, supported by foundational elements from computer science and math/statistics. A focus area prepares students for application of data science within a specific discipline. The structure of the degree simultaneously promotes the broad nature of data science, while allowing students to gain depth of knowledge on their preferred career path.

Fig. 1. Foundational pillars of Data Science degree.

The program requires 120 credits (plus co-curricular requirements). The curriculum has 55-57 credits in the data science core (including 6 credits in content related to communication, context and ethics and 3 credits for a capstone experience), 12 elective credits in data science courses, 15 credits in a technical focus area, 5-7 credits of free electives, and 39 credits of General Education (note, 8 credits of the general education requirements are included in the major requirements).

The technical focus area provides the opportunity for all graduates of the program to also earn a minor. For example, students completing the Software Engineering focus can earn a minor in Computer Science, students in Cybersecurity and Statistics focus areas can earn those

respective minors, and students in the Business Technology focus area can earn the Business IT Solutions minor. Other focus areas options are possible, including allowing students to design their own (with consultation and approval from the program director). Our intent is to create more prescribed focus area/minor combinations over time consulting with other units on campus. Additionally, depending on course selections, some students not pursuing the Statistics focus area could complete a second minor in Statistics.

The Data Science program student outcomes given below reference and align with the ACM Data Science Task Force (DSTF) Report[1] and ABET student outcomes for Data Science programs.[2] The ACM DSTF Report builds upon prior work in defining data science curricula from the EDISON project[3,4], National Academies of Science, Engineering, and Medicine Report[5], and the Park City Report. [6]

By the completion of the program, students will be able to:

a. Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions.

b. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.

c. Communicate effectively in a variety of professional contexts.

d. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.

e. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

f. Apply theory, techniques and tools throughout the data science lifecycle and employ the resulting knowledge to satisfy stakeholders' needs.

---

[1] ACM Data Science Task Force https://dstf.acm.org/

[2] ABET accredits Data Science programs through both the Applied and Natural Science Accreditation Commission (ANSAC) and Computing Accreditation Commission (CAC)
https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-applied-and-natural-science-programs-2022-2023/
https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-computing-programs-2022-2023/

[3] Demchenko, Y. et al. 2016. Edison Data Science Framework: Part 1. Data Science Competence Framework (Cf-Ds) Release 1. (Jan. 2016). https://doi.org/10.5281/zenodo.167585

[4] EDISON: building the data science profession. https://edison-project.eu/ Accessed: 2022-09-15

[5] National Academies of Sciences, Engineering, and Medicine. 2018. Envisioning the Data Science Discipline: The Undergraduate Perspective: Interim Report. Washington, DC: The National Academies Press. https://doi.org/10.17226/24886.

[6] Veaux, R.D.D. et al. 2017. Curriculum Guidelines for Undergraduate Programs in Data Science. Annual Review of Statistics and Its Application. 4, 1 (2017), 15–30. https://doi.org/10.1146/annurev-statistics-060116-053930

5. Title of the Program: Data Science (B.S.)

6. Rationale:

Data Science is a rapidly growing field. A number of reports from the U.S. Department of Labor's Bureau of Labor Statistics (BLS) highlights the growth of jobs in data science. In 2018, the BLS stated that statisticians, with an understanding of big data, are "projected to grow the fastest of any occupation in this mathematical group, at 33.8% from 2016 to 2026."[7] In Sept. 2022, the Occupational Outlook Handbook states that the job outlook for data scientists is strong with a projected growth of "36% from 2021 to 2031, much faster than the average for all occupations".[8]

Additionally, these positions have a median annual wage of $100,901 in May 2021, with a Bachelor's degree as the typical entry-level education.[8] Additionally, Data Scientist was ranked #6 in the 100 Best Jobs list in 2022 by U.S. News and World Report.[9] Glassdoor ranks Data Scientist #3 in the 50 Best Jobs in America for 2022.[10]

The proposed Data Science BS degree includes foundational coursework from both Computer Science and Mathematical Sciences. However, the degree differs significantly from the existing Mathematics and Computer Science degree (SMCS). The proposed degree adds new courses focused on data science skills, expands the course options to broader data science topics taught outside of these departments, and requires students to have some technical focus area (a domain specialization required for ABET accreditation).

Graduates would also have a strong foundation to continue their studies into a graduate program such as Michigan Tech's M.S. in Data Science, M.S. in Statistics, M.S. in Applied Statistics, or M.S. in Health Informatics.

7. Related Programs within the Institution and in the Region:

a. At Michigan Tech

The closest related program is B.S. in Mathematics and Computer Science (degree audit code SMCS). Other related undergraduate programs include: Computer Science (SCS2), Business Analytics, Mathematics-Business Analytics (SMA0) and Statistics (SST). Additionally, the College of Forest Resources and Environmental Science (CFRES) is developing a proposal for "Environmental Data Science" in parallel to this proposal.[11]

---

[7] U.S. Bureau of Labor Statistics. https://www.bls.gov/opub/btn/volume-7/big-data-adds-up.htm
[8] U.S. BLS, Occupational Outlook Handbook. https://www.bls.gov/ooh/math/data-scientists.htm
[9] U.S. News and World Report. https://money.usnews.com/careers/best-jobs/rankings/the-100-best-jobs
[10] Glassdoor.com https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm
[11] Note, that the College of Computing fully supports the proposed Environmental Data Science program and hope that other units will also develop data science programs more deeply couched within a given discipline. We believe that data science is broad enough for there to be room for both, which will elevate the visibility and overall quality of both our offerings.

In addition to undergraduate programs, Michigan Tech has several related graduate programs: MS and graduate certificate in Data Science, MS and graduate certificate in Applied Statistics, MS and PhD in Computer Science, MS and PhD in Statistics, and PhD in Computational Science and Engineering.

b. In the Region

The number of Data Science programs is growing in the region. Among the Michigan Association of State Universities (MASU), there are Data Science programs at:

i. Central Michigan University - Major in Data Science
https://www.cmich.edu/program/Data-Science-(Major)

ii. Eastern Michigan University - BS in Data Science and Analytics
https://www.emich.edu/programs/data-science-analytics.php

iii. Ferris State University – MS in Data Science and Analytics
https://www.ferris.edu/business/data-science-analytics-ms/homepage.htm

iv. Grand Valley State University – MS in Data Science and Analytics
https://www.gvsu.edu/acad/data-science-and-analytics-ms.htm

v. Lake Superior State University - BS in Data Science
https://www.lssu.edu/college-innovation-solutions/school-math-computer-science/data-science/

vi. Michigan State University - BS in Data Science
https://cmse.msu.edu/academics/undergraduate-program/bachelor-of-science-degree-in-data-science/

vii. Northern Michigan University – BS in Data Science
https://nmu.edu/bulletin/data-science-major

viii. Oakland University - MS in Business Analytics
https://oakland.edu/business/graduate-executive-programs/master-of-science-in-business-analytics/

ix. University of Michigan - Ann Arbor - BS, MS in Data Science
BS: https://cse.engin.umich.edu/academics/undergraduate/data-science-eng/
BA: https://cse.engin.umich.edu/academics/undergraduate/data-science-lsa/
MS: https://cse.engin.umich.edu/academics/graduate/masters-in-data-science/
MS in Applied Data Science: https://www.si.umich.edu/programs/master-applied-data-science

x. University of Michigan – Dearborn – BS, MS in Data Science
https://umdearborn.edu/cecs/departments/computer-and-information-science/undergraduate-programs/bs-data-science
https://umdearborn.edu/cecs/departments/computer-and-information-science/graduate-programs/ms-data-science

xi. University of Michigan – Flint – BS, MS in Data Analytics
https://www.umflint.edu/cas/data-analytics/

xii. Wayne State University – MS in Data Science and Analytics
https://engineering.wayne.edu/data-science-program

xiii. Western Michigan University - BS in Data Science
https://wmich.edu/statistics/data-science-major

Other programs in the region include:

i. University of Wisconsin – BS, BA in Data Science
https://stat.wisc.edu/undergraduate-data-science-studies/
ii. University of Minnesota – BS in Data Science
https://cse.umn.edu/college/data-science
iii. University of Illinois – Urbana Champaign – X + DS programs
https://datascience.illinois.edu/academics

c. Nationwide

Data Science programs have seen tremendous growth nationwide in the past decade. A report by the South Big Data Hub stated in 2018 that there were 563 Data Science program at 349 institutions with most 396 MS programs and only 50 Bachelors programs. [12] In the intervening years, Data Science BS programs have been rapidly expanding. The Academic Data Science Alliance (ADSA) has tracked over 190 new programs, certificates, institutes, centers, and initiatives since July 2021. [13] University of California – Berkeley has been a leader in undergraduate Data Science education. Many other universities have gifts and plans to add Data Science programs, institutes and centers including:

i. University of California - Berkeley – BS, MS in Data Science
https://guide.berkeley.edu/undergraduate/degree-programs/data-science/
ii. University of Virginia – Minor, MS, PhD in Data Science
https://datascience.virginia.edu/academics
iii. University of California – San Diego – BS, MS, PhD in Data Science
https://datascience.ucsd.edu/academics/
iv. Northeastern University – BS, MS in Data Science, BS in DS/X
https://www.khoury.northeastern.edu/programs/data-science-bs/

8. Projected Enrollment:

Computer Science has 21 full-time tenured or tenure-track faculty and 2 full-time teaching faculty.[14] The faculty supports 554 undergraduate student majors in multiple departmental degree programs (computer science and software engineering) and shared degree programs (cybersecurity, mathematics and computer science). Over the last three years (since the creation of the College of Computing), undergraduate enrollment has been 519, 541, 554 and graduate enrollment of 72, 77, 77.

Because mathematics and statistics are integral to the Data Science program some details are also included here. Mathematical Sciences has 24 tenured or tenure-track faculty and 6

[12] Presented at the National Workshop on Data Science Education 2019. https://data.berkeley.edu/academics/resources/data-science-education-resources/2019-national-workshop-data-science-education
[13] Academic Data Science Alliance. https://academicdatascience.org/
[14] Data from 2021-22 Michigan Tech Institutional Research Compendium https://www.mtu.edu/institutional-research/compendium/

teaching faculty members. The faculty supports 68 undergraduate student majors in 2021-22. Undergraduate enrollment over the past five years was 91, 88, 87, 82, and 68 from 2017-18 to 2021-22; graduate enrollment was 44, 49, 72, 104, 99 over the same time period.

We expect enrollment for the program to grow quickly with a minimum of 20 students the first year, and 50, 85, and 125+ students over the following years. Note, we can compare this projected enrollment against the realized enrollment for the recently introduced BS in Cybersecurity with enrollments of 13, 40, 76, 112 from Fall 2019 to Fall 2022 to show that the projections are reasonable.

The growth of students in the following courses will require additional resources. Adding 40 students a year to courses such as, MA 2320, MA 2320, MA 3720, MA 3740, MA 4710, CS 1121, CS 2321, CS 3425, CS 4321, etc. will require another section or lab section be available. Additional discussion on needs to support the program is described in Sections 12, 13 and 14.

9. Curriculum Design:

The proposed B.S. in Data Science is structured around the following main components (see Figure 2 below):

- Data Science Core, 17-18 courses, 55-57 credits
    - Computer Science (CS), 5-6 courses, 17-18 credits
    - Mathematics, 5 courses, 15-16 credits
    - Data Science, 6 courses, 17 credits
    - Communication, Context, and Ethics, 2 courses, 6 credits
- Data Science Electives, 4 courses, 12 credits
- Focus Area, 5 courses, 15 credits
- Free Electives, 5-7 credits
- General Education (GenEd) requirements, ~12 courses, 39 – 8 = 31 credits
  In the GenEd STEM requirements, the mathematics (4 cr.) and restricted-STEM (4 cr.) list courses are included as part of the data science core.

The degree requires a total of 120 credits + 3 co-curriculars at minimum.

The focus area (5 courses, 15 credits) allows students to specialize and gain deeper knowledge in an area or domain. Each focus area, along with data science core and specific electives, will cover most of the requirements for a minor, e.g.,

- a minor in computer science for the software engineering focus area,
- a minor in statistics for the statistics focus area,
- a minor in cybersecurity for the cybersecurity focus area, or
- a minor in business IT solutions, or design their own focus area.

Additionally, some data science students could complete a second minor in statistics depending on the careful choice of data science and free electives. A minor in statistics would make use of MA 3720, MA 2720 in the math core, and selecting MA 3740 and three (3) 4000-level math courses from (MA 4710, MA 4720, MA 4730, MA 4760, MA 4770, MA 4780, MA 4790). Courses cannot be double counted between minors.

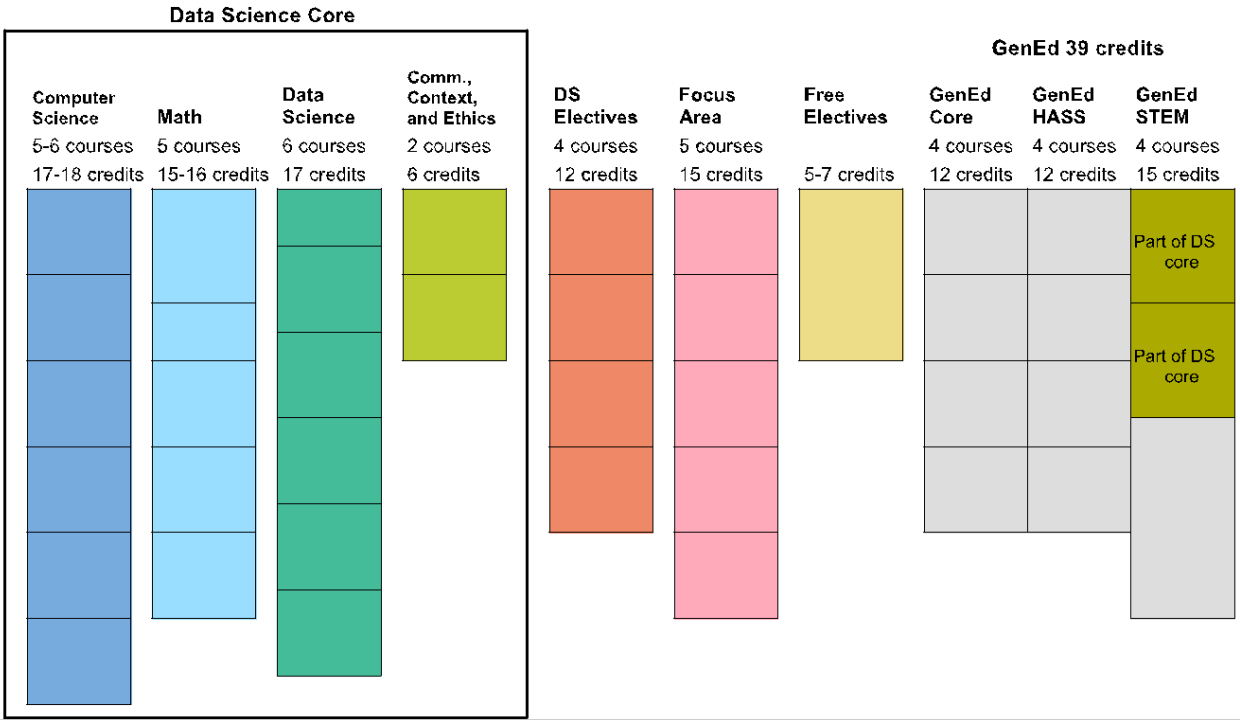

Figure 2. Overview of Data Science Curricular Requirements

Course Requirements

Bolded prefix and course numbers are for newly proposed courses.

Data Science Core: 17-18 courses, 55-56 credits

Computer Science: 5-6 courses, 17-18 credits

- Intro Programming Seq: (CS 1121 AND CS 1122) OR CS 1131

  [CS 1121 3 cr. Introduction to Programming I
  F,S,Su
  Prereqs: MA 1031(C) or MA 1032(C) or MA 1120(C)

  AND

  CS 1122 3 cr. Introduction to Programming II
  F,S,Su
  Prereqs: CS 1122]

  OR

  CS 1131 5 cr. Accelerated Introduction to Programming
  F
  Prereqs: MA 1031(C) or MA 1032(C) or MA 1120(C) or MA 1160(C) or MA 1161(C) or MA 1121(C)

- CS 2311 3 cr. Discrete Structures
  OR F,S
  Prereqs: (CS 1121 or CS 1131) and (MA 1135 or MA 1160 or MA 1161 or MA 1121 or MA 2160)

  MA 3310 3 cr. Introduction to Combinatorics
  F,Su
  Prereqs: MA 2320 or MA 2321 or MA 2330

- CS 2321 3 cr. Data Structures
  F,S
  Prereqs: CS 1122 or CS 1131
- CS 3425 3 cr. Introduction to Database Systems
  OR F,S
  Prereqs: (CS 2311 or MA 3210) and CS 2321
  SAT 3210 3 cr. Database Management
  F
  Prereqs: SAT 1200 or CS 1111 or CS 1121 or CS 1131 or CS 1142 or MIS 2100
- CS 4321 3 cr. Introduction to Algorithms
  F,S
  Prereqs: (CS 2311 or MA 3210) and CS 2321

Mathematics: 5 courses, 15-16 credits

- MA 1160 4 cr. Calculus I
  F
  Prereqs: MA 1032 or MA 1031 or MA 1120 or Placement
- MA 2320 2 cr. Elementary Linear Algebra
  OR F,S,Su
  Prereqs: MA 1160 or MA 1161 or MA 1135 or MA 1121
  MA 2330 3 cr. Linear Algebra
  F,S
  Prereqs: MA 1160 or MA 1161 or MA 1135 or MA 1121
- MA 2710 3 cr. Introduction to Statistical Analysis
  S
  Prereqs: MA 1160 or MA 1161 or MA 1135 or MA 1121
- MA 3720 3 cr. Probability
  F,Su
  Prereqs: MA 1160 or MA 1161 or MA 1121
- Select one of:
  MA 3740 3 cr. Statistical Programming and Analysis
  OR F,S
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715
  MA 4710 3 cr. Regression Analysis
  OR F
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701
  MA 4790 3 cr. Predictive Modeling
  F,S
  Prereqs: MA 3740 or MA 4710 or MA 4720 or MA 4780

Data Science: 6 courses, 17 credits

- **DS 1201** 2 cr. Data Science Programming I
  NEW 23-24
  Prereqs: MA 1031(C) or MA 1032(C) or MA 1120(C)
- **DS 1202** 3 cr. Data Science Programming II
  NEW 23-24
  Prereqs: DS 1201 and (CS 1121 or CS 1131 or CS 1111)

- **DS 2201** 3 cr. Foundations of Data Science
  NEW 24-25
  Prereqs: DS 1202 and (CS 1122 or CS 1131) and (MA 2320 or MA 2330)
- **DS 3801** 3 cr. Foundations of Machine Learning
  NEW 25-26
  Prereqs: DS 2201 and CS2321 and (MA 2320 or MA 2330) and MA 2710 and MA 3720
- **DS 3401** 3 cr. Data Engineering
  NEW 25-26
  Prereqs: (CS 3425 or SAT 3210) and DS 2201
- **DS 4891** 3 cr. Data Science Capstone
  NEW 25-26
  Level: Senior

Communication, Context, and Ethics: 2 courses, 6 credits

- HU 2645 3 cr. Graphic and Information Design
  OR F,S
  Prereqs: None
  MIS 3500 3 cr. User-Centered Design
  OR D
  Prereqs: MIS 2000 or MIS 2100 or CS 1122 or CS 1131
  DS 2600 3 cr. Visualization
  NEW 26-27
  Prereqs: DS 2201 and UN 1015
- CS 3000 3 cr. Ethical and Social Aspects of Computing OR
  F,S
  Prereqs: CS 3141
  SAT 1700 3 cr. Cyber Ethics
  OR F
  Prereqs: None
  DS 3000 3 cr. Data Science Ethics
  NEW 27-28
  Prereqs: DS 2101 or CS 3141

Data Science Electives: 4 courses, 12 credits
At most 6 credits 2000-3000 level

Select one course from a list of Machine Learning / AI related topics:

- CS 4811 3 cr. Artificial Intelligence
  F,S
  Prereqs: CS 2311 and CS 2321 and (CS 3411 or CS 3421 or CS 3425 or CS 3331)
- CS 4821/CS 5831 3 cr. Data Mining
  S
  Prereqs: (CS3425 or MIS3100) and (MA2330 or MA2320 or MA2321) and (MA2710 or MA2720 or MA3710)
- CS 5811 3 cr. Adv. Artificial Intelligence
  F
  Prereqs: CS 4811

- CS 5821 3 cr. Computational Intelligence
  D
  Prereqs: None
- CS 5841 3 cr. Machine Learning
  S
  Prereqs: CS 4821
- EET 4501 3 cr. Applied Machine Learning
  S
  Prereqs: SAT 4310 or SAT 4650 or CS 1121

Select three remaining courses (includes any course above not counted towards the ML/AI requirement):

- CS 3141 3 cr. Team Software Project
  F,S
  Prereqs: (CS 2311 or MA 3210) and CS 2321
- CS 4001 3 cr. National Cybersecurity Policy and Law
  F
  Prereqs: None; Level Restriction: Senior
- CS 4471 3 cr. Computer Security
  F
  Prereqs: CS 3411 or CS 4411
- CS 4760 3 cr. User Interface Design and Implementation
  S
  Prereqs: CS 3141
- MA 2600 3 cr. Scientific Computing
  F
  Prereqs: MA 2160 and (MA 2320 or MA 2321 or MA 2330)
- MA 3740 3 cr. Statistical Programming and Analysis
  F,S
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715
- MA 4330 3 cr. Linear Algebra
  F
  Prereqs: (MA 2320 or MA 2331 or MA 2330) and MA 3160
- MA 4710 3 cr. Regression Analysis
  F
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701
- MA 4720 3 cr. Design and Analysis of Experiments
  Sp,Su
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701
- MA 4760 3 cr. Mathematical Statistics I
  F
  Prereqs: MA 3720 or EE 3180
- MA 4770 3 cr. Mathematical Statistics II
  S
  Prereqs: MA 4760

- MA 4780/MA 5780 3 cr. Time Series Analysis and Forecasting
  S
  Prereqs: (MA 2710 or MA 2720 or MA 3710 or MA 3715) and (MA 3720 or EE 3180)
- MA 4790/MA 5790 3 cr. Predictive Modeling
  F,S
  Prereqs: MA 3740 or MA 4710 or MA 4720 or MA 4780
- SAT 2711 3 cr. Linux Fundamentals
  OR F,Su
  Prereqs: SAT 1200 or CS 1111(C) or CS 1121 or CS 1131 or CS 1142 or MIS 2100
  SAT 3310 3 cr. Scripting for Administration, Automation, and Security
  S
  Prereqs: SAT 1200 or CS 1111 or CS 1121 or CS 1131 or CS 1142 or MIS 2100
- SAT 3812 3 cr. Cyber Security I
  F,S,Su
  Prereqs: SAT 1200 or CS 1111 or CS 1121 or CS 1131 or CS 1142 or MIS 2100
- SAT 4144 3 cr. Artificial Intelligence in Healthcare
  S,even
  Prereqs: SAT 4650
- SAT 4283 3 cr. Information Governance and Risk Management
  F
  Prereqs: None
- SAT 5165 3 cr. Introduction to Big Data Analytics
  S
  Prereqs: SAT 4650
- MIS 4000 3 cr. Emerging Technologies
  F,even
  Prereqs: (MIS 2100 and MIS 3200(C)) or (CS 2321 and CS 3141)
- MIS 4400 3 cr. Business Intelligence and Analytics
  D
  Prereqs: (MIS 2100 or CS 1122 or CS 1131) and (MIS 3100 or CS 3425)

Note, we expect as enrollment grows to be able to introduce additional new courses in topics such as deep learning, cloud computing, information storage and retrieval, natural language processing, and more.

Also, additional disciplinary focused data science courses will be added in consultation with other units around campus.

Free Electives: 5-7 credits

General Education Courses: 39 credits – 8 credits = 31 credits
Students will complete 12 credits from Core, 12 credits from HASS, and 15 credits of STEM (4 credits from mathematics and a minimum of 7 credits from Science, including one lab science). The Core and HASS courses are divided as:

- UN 1015 3 cr. Composition
- UN 1025 3 cr. Global Issues OR 3000-level or higher Modern Language course
- 3 cr. Creative and Critical Thinking list
- 3 cr. Social Responsibility and Ethical Reasoning list

HASS – 12 credits

- 3 cr. Communication and Composition list
- 3 cr. Humanities and Fine Arts (HUFA) list
- 3 cr. Social and Behavioral Sciences, SBS (EC/PSY/SS) list
- 3 cr. HASS elective list

The STEM requirements include a minimum of 15 credits, at least 4 credits mathematics, at least two courses in different disciplines from the Science list (minimum 7 credits and at least one must include a lab).

- 4 cr. Mathematics list part of DS core
- 7 cr. Science list
- 4 cr. Restricted STEM list part of DS core

Focus Areas: 5 courses, 15 credits

Students must complete the requirements in a focus area. Each focus area is designed to align with minors to enable students to complete a minor without additional time for their degree. Students would use 15 credits from the focus area and 3+ credits from the data science core and/or free electives courses.

Software Engineering (students could complete CS minor)

Use *CS 3141 Team Software Project* from the data science electives list and:

- CS 1142 3 cr. Programming at the HW/SW Interface
  F,S,Su
  Prereqs: CS 1122 or CS 1131

Select 12 credits from the following

- CS 3311 3 cr. Formal Models of Computation
  F,S
  Prereqs: CS 2311 or MA 3210
- CS 3712 3 cr. Software Quality Assurance
  S
  Prereqs: CS 3141
- CS 4710 3 cr. Model-Driven Software Development
  F,S
  Prereqs: CS 3311 and CS 3141(C)
- CS 4711 3 cr. Software Processes and Management
  F
  Prereqs: CS 3141
- CS 4760 3 cr. User Interface Design and Implementation
  S
  Prereqs: CS 3141

Cybersecurity (student could complete Cybersecurity minor)
Use *SAT 3812 Cybersecurity I* from the data science electives list and:

- CS 1111 3 cr. Introduction to Programming in C/C++
  OR F,Su
  Prereqs: None; Major Restrictions
  CS 1142 3 cr. Programming at the Hardware Software Interface OR
  F,S,Su
  Prereqs: CS 1122 or CS 1131
  MIS 2100 3 cr. Introduction to Business Programming
  F
  Prereqs: BUS 1100 or CS 1121 or CS 1131 or ENG 1101 or (ENG 1001 and ENG 1100) or SAT 1200

Select two or more:

- CS 4471 3 cr. Computer Security
  F
  Prereqs: CS 3411 or CS 4411
- EE 4723 3 cr. Network Security
  S
  Prereqs: EE 4272 or CS 4461 or SAT 4812
- MA 3203 3 cr. Introduction to Cryptography
  S,Su
  Prereqs: MA 2320 or MA 2321 or MA 2330
- SAT 4812 3 cr. Cybersecurity II
  S
  Prereqs: SAT 3812

Select zero-two:

- CS 3712 3 cr. Software Quality Assurance
  S
  Prereqs: CS 3141
- CS 4471 3 cr. Computer Security
  F
  Prereqs: CS 3411 or CS 4411
- CS 4710 3 cr. Model-driven Software Development
  F,S
  Prereqs: CS 3311 and CS 3141(C)
- MIS 4200 3 cr. Management of Cyber Security
  F,odd
  Prereqs: MIS 2000 or MIS 2100 or CS 1111 or CS 1122 or CS 1131
- SAT 2711 3 cr. Linux Fundamentals
  F,Su
  Prereqs: SAT 1200 or CS 1111(C) or CS 1121 or CS 1131 or CS 1142 or MIS 2100
- SAT 3310 3 cr. Scripting for Administration, Automation, and Security
  S
  Prereqs: SAT 1200 or CS 1111 or CS 1121 or CS 1131 or CS 1142 or MIS 2100

Statistics (students could complete a Statistics minor)

Use *MA2710*, *MA3720,* and one of {*MA 3740, MA 4710, MA 4790*} from data science core and:

- MA 3740 3 cr. Statistical Programming and Analysis
  F,S
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715

Group A: Select two (2) - three (3):

- MA 4710 3 cr. Regression Analysis
  F
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701
- MA 4720 3 cr. Design and Analysis of Experiments
  S,Su
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715 or MA 5701
- MA 4730 3 cr. Nonparametric Statistics
  F,odd
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715
- MA 4760 3 cr. Mathematical Statistics I
  F
  Prereqs: MA 3720 or EE 3180
- MA 4770 3 cr. Mathematical Statistics II
  S
  Prereqs: MA 4760
- MA 4780 3 cr. Time Series Analysis and Forecasting
  S
  Prereqs: (MA 2710 or MA 2720 or MA 3710 or MA 3715) and (MA 3720 or EE 3180)
- MA 4790 3 cr. Predictive Modeling
  F,S
  Prereqs: MA 3740 or MA 4710 or MA 4720 or MA 4780

Group B: Select one (1) – two (2) from below (or additional course from above sections):

- MA 2600 3 cr. Scientific Computing
  F
  Prereqs: MA 2160 and (MA 2320 or MA 2321 or MA 2330)
- MA 3203 3 cr. Introduction to Cryptography
  S,Su
  Prereqs: MA 2320 or MA 2321 or MA 2330
- MA 3310 3 cr. Introduction to Combinatorics
  F,Su
  Prereqs: MA 2320 or MA 2321 or MA 2330
- Any upper-level Math course (4000-level)

Note, if a student took MA 3740 to fulfill their DS core course, then they would select three courses from Group A and one course from Group B. If a student took MA 4710 or MA 4790 to fulfill their DS core course, then they would select two from Group A and two from Group B.

<u>Business Technology</u> (students could complete a Business IT Solutions minor)
Use *CS 1121 or CS 1131 Introduction to Programming* from the data science core list and:

- MIS 2000 3 cr. IS/IT Management
  F,S,Su
  Prereq: BUS 1100 or CS 1121 or CS 1131 or ENG 1101 or (ENG 1001 and ENG 1100) or SAT 1200

- MIS 3100 3 cr. Business Database Management S
  Prereq: MIS 2000(C) or MIS 2100 or CS 1122 or CS 1131
- MIS 3200 3 cr. Systems Analysis and Design F
  Prereq: MIS 2000(C) or MIS 2100(C) or CS 1122 or CS 1131

Select two from one of the elective areas

- Usability and Human Factors in IT Design
  - MIS 2200 3 cr. Web Programming D
    Prereqs: MIS 2100 or CS 1122 or CS 1131
  - MIS 3500 3 cr. User-Centered Design D
    Prereqs: MIS 2000 or MIS 2100 or CS 1122 or CS 1131
  - HU 2642 3 cr. Introduction to Digital Media F
    Prereqs: None
  - HU 3120 3 cr. Tech. and Prof. Communication F,S,Su
    Prereqs: UN 1015 and (UN 1025 or Modern Language - 3000 level or higher)
  - HU 4628 3 cr. Usability Evaluation and User Experience Design S
    Prereqs: (HU 3120 or HU 3121) and UN 1015 and (UN 1025 or Modern Language 3000+level)
  - HF 3850 3 cr. Human Factors F
    Prereqs: PSY 2000 or HF 2000
  - HF 4015 3 cr. Cognitive Task Analysis F
    Prereqs: PSY 2000 or HF 2000
- Systems Thinking for Design
  - MIS 3500 3 cr. User-Centered Design D
    Prereqs: MIS 2000 or MIS 2100 or CS 1122 or CS 1131
  - MIS 4000 3 cr. Emerging Technologies F,even
    Prereqs: (MIS 2100 and MIS 3200(C)) or (CS 2321 and CS 3141)
- Data and IT
  - MIS 4400 3 cr. Business Intelligence and Analytics D
    Prereqs: (MIS 2100 or CS 1122 or CS 1131) and (MIS 3100 or CS 3425)
  - MIS 4000 3 cr. Emerging Technologies F,even
    Prereqs: (MIS 2100 and MIS 3200(C)) or (CS 2321 and CS 3141)
  - MA 2330 3 cr. Linear Algebra

    Prereqs: MA 1160 or MA 1161 or MA 1135 or MA 1121

- MA 3740 3 cr. Statistical Programming and Analysis
  Prereqs: MA 2710 or MA 2720 or MA 3710 or MA 3715

* Courses cannot be double counted between minors. Therefore, if a student is interested in both a Statistics minor and the Business IT Solutions minor, they cannot use MA 2330 and MA 3740 in the Business Technology focus area.

Design your own Focus Area
Students would make a plan with advisor and program director for a selection of 5 courses in their technical focus area, e.g., forestry, biology, financial technology, physics, chemistry, engineering, etc.

10. New Course Descriptions:
The B.S. in Data Science includes 6 new courses as major requirements and 2 new courses as optional major requirements. Note, these courses would not all be required in the first year of initiating the degree program, but would instead be rolled out over 5 years. The course proposal sheets those in the first two years are included in the appendix; the additional courses will go through the standard binder process during the remaining 3 years.

Major requirements
DS 1201 – Data Science Programming I (2 cr.) 2023-24
Data Science Programming I introduces students to data science topics. The course introduces computer programming in Python using real-world examples and datasets. Topics include: use of linux computers, use of the command line, etc. that will provide tools for the data science discipline.
Prereqs: MA 1031(C) or MA 1032(C) or MA 1120(C) or MA 1060(C)

DS 1202 – Data Science Programming II (3 cr.) 2023-24
Data Science Programming II continues to introduce students to data science topics including inferential and computational thinking. Students will expand their understanding of working with data in Python. Topics include data types, table operations, functions, conditional statements, iteration, sampling, testing and debugging.
Prereqs: DS 1201 and (CS 1121 or CS 1131 or CS 1111)

DS 2201 – Foundations of Data Science (3 cr.) 2024-25
Introduces data science technologies and methods that provide a foundation for subsequent Data Science classes. Topics covered include working with data and applied linear algebra in standard numerical computing libraries.
Prereqs: DS 1202 and (CS 1122 or CS 1131)

DS 3801 – Foundations of Machine Learning (3 cr.) 2025-26

Foundations of Machine Learning explores concepts of data science across the data science lifecycle. Topics include problem formulation, visualization, statistical inferences, introduction to machine learning topics (regression, clustering, classification), and decision making.
Prereqs: DS 2201 and CS2321 and (MA 2320 or MA 2330) and MA 2710 and MA 3720

DS 3401 – Data Engineering (3 cr.) 2025-26
The course covers topics related to the design and build of data models, data pipelines, and working with large amounts of data.
Prereqs: (CS 3425 or SAT 3210) and DS 2201

DS 4891 – Data Science Capstone (3 cr.) 2025-26
A capstone project course. Data Science students will work as a team utilizing data science skills and methods work through the data science lifecycle on a project.
Prereqs: DS 3801 and DS 3401
Level: Senior

Additional New Courses
DS 2600 – Visualization (3 cr.) 2026-27
The course covers principles of visualization and design. Students will learn visualization tools across multiple programming languages, e.g., Python and R as well as stand-alone software, e.g., Tableau.
Prereqs: DS 2201

DS 3000 – Data Science Ethics (3 cr.) 2027-28
An exploration of the ethical issues and impacts of data science on society. Topics include ethical theories, privacy, security, fairness, bias, and professional responsibility.
Prereqs: DS 3801(C)

11. Model Schedules:
Sample schedules for each focus area are provided. Each schedule is for 120 credits of coursework with 3 credits of co-curriculars. Note, the provided schedules are templates to meet prerequisite requirements, but have some flexibility within the curriculum.

Model Schedules are also included as an Appendix A.

Data Science – Software Engineering Focus

Year 1	
Fall: 15.5 credits ● CS 1121 Intro to Programming I ● MA 1160 Calculus I ● DS 1201 Data Science Programming I ● UN 1015 Composition ● GenEd Crit. And Creative Thinking ● Co-curricular	Spring: 14.5 credits ● CS 1122 Intro to Programming II ● MA 2320 Elementary Linear Algebra ● MA 2710 Intro to Statistical Analysis ● DS 1202 Data Science Programming II ● UN 1025 Global Issues ● Co-curricular

Year 2	
Fall: 16.5 credits ● CS 2311 Discrete Structures ● CS 2321 Data Structures ● MA 3720 Probability ● DS 2201 Foundations of Data Science ● Lab Science ● Co-curricular	Spring: 15.5 credits ● CS 3425 Intro to Database Systems ● DS CCE Viz/UX course ● CS 1142 Prog. at the HW/SW Interface ● CS 3311 Formal Models ● Lab Science ● Co-curricular
Year 3	
Fall: 15.5 credits ● DS 3801 Foundations of Machine Learning ● DS CCE Ethics ● CS 3141 Team Software Project ● GenEd Social and Ethical Reasoning ● GenEd Comm/Composition ● Co-curricular	Spring: 15.5 credits ● CS 4321 Intro to Algorithms ● DS 3401 Data Engineering ● DS elective ● CS 3712 Software Quality Assurance ● GenEd HUFA ● Co-curricular
Year 4	
Fall: 15 credits ● MA Elective ● CS 4710 Model-driven Soft. Dev / CS 4711 Software Proc. and Mgmt. ● DS Elective ● Free Elective ● GenEd Soc. And Behavioral Science	Spring: 15 credits ● DS 4891 Capstone ● DS Elective – ML / AI ● CS 4760 User Interface Design ● Free Elective ● GenEd HASS elective

Data Science – Cybersecurity Focus

Year 1	
Fall: 15.5 credits ● CS 1121 Intro to Programming I ● MA 1160 Calculus I ● DS 1201 Data Science Programming I ● UN 1015 Composition ● GenEd Crit. And Creative Thinking ● Co-curricular	Spring: 14.5 credits ● CS 1122 Intro to Programming II ● MA 2320 Elementary Linear Algebra ● MA 2710 Intro to Statistical Analysis ● DS 1202 Data Science Programming II ● UN 1025 Global Issues ● Co-curricular
Year 2	
Fall: 16.5 credits ● CS 2311 Discrete Structures ● CS 2321 Data Structures ● MA 3720 Probability ● DS 2101 Foundations of Data Science ● Lab Science	Spring: 15.5 credits ● CS 3425 Intro to Database Systems ● DS CCE Viz/UX course ● CS 1142 Prog. at the HW/SW Interface ● MA 3203 Intro to Cryptography ● Lab Science

● Co-curricular	● Co-curricular
Year 3	
Fall: 15.5 credits ● DS 3801 Foundations of Machine Learning ● DS CCE Ethics ● SAT 2711 Linux Fundamentals ● GenEd Social and Ethical Reasoning ● GenEd Comm/Composition ● Co-curricular	Spring: 15.5 credits ● CS 4321 Intro to Algorithms ● DS 3401 Data Engineering ● DS elective ● SAT 3812 Cybersecurity I ● GenEd HUFA ● Co-curricular
Year 4	
Fall: 15 credits ● MA Elective ● DS Elective ● Cybersec Elective ● Free Elective ● GenEd Soc. And Behavioral Science	Spring: 15 credits ● DS 4891 Capstone ● DS Elective – ML / AI ● SAT 4812 Cybersecurity II ● Free Elective ● GenEd HASS elective

Data Science – Statistics Focus

Year 1	
Fall: 15.5 credits ● CS 1121 Intro to Programming I ● MA 1160 Calculus I ● DS 1201 Data Science Programming I ● UN 1015 Composition ● GenEd Crit. And Creative Thinking ● Co-curricular	Spring: 14.5 credits ● CS 1122 Intro to Programming II ● MA 2320 Elementary Linear Algebra ● MA 2710 Intro to Statistical Analysis ● DS 1202 Data Science Programming II ● UN 1025 Global Issues ● Co-curricular
Year 2	
Fall: 16.5 credits ● CS 2311 Discrete Structures ● CS 2321 Data Structures ● MA 3720 Probability ● DS 2201 Foundations of Data Science ● Lab Science ● Co-curricular	Spring: 15.5 credits ● CS 3425 Intro to Database Systems ● DS CCE Viz/UX course ● MA 3740 Statistical Prog. & Analysis ● GenEd Social and Ethical Reasoning ● Lab Science ● Co-curricular
Year 3	
Fall: 15.5 credits ● DS 3801 Foundations of Machine Learning ● DS CCE Ethics ● DS Elective ● Statistics Elective	Spring: 15.5 credits ● CS 4321 Intro to Algorithms ● DS 3401 Data Engineering ● DS elective ● MA 47XX

● GenEd Comm/Composition ● Co-curricular	● GenEd HUFA ● Co-curricular
Year 4	
Fall: 15 credits ● MA Elective ● DS Elective ● MA 47YY ● Free Elective ● GenEd Soc. And Behavioral Science	Spring: 15 credits ● DS 4891 Capstone ● DS Elective – ML / AI ● MA 47ZZ ● Free Elective ● GenEd HASS elective

Data Science – Business Technology Focus

Year 1	
Fall: 15.5 credits ● CS 1121 Intro to Programming I ● MA 1160 Calculus I ● DS 1201 Data Science Programming I ● UN 1015 Composition ● GenEd Crit. And Creative Thinking ● Co-curricular	Spring: 14.5 credits ● CS 1122 Intro to Programming II ● MA 2320 Elementary Linear Algebra ● MA 2710 Intro to Statistical Analysis ● DS 1202 Data Science Programming II ● UN 1025 Global Issues ● Co-curricular
Year 2	
Fall: 16.5 credits ● CS 2311 Discrete Structures ● CS 2321 Data Structures ● MA 3720 Probability ● DS 2201 Foundations of Data Science ● Lab Science ● Co-curricular	Spring: 15.5 credits ● CS 3425 Intro to Database Systems ● DS CCE Viz/UX course ● MIS 2000 IS/IT Management ● GenEd Social and Ethical Reasoning ● Lab Science ● Co-curricular
Year 3	
Fall: 15.5 credits ● DS 3801 Foundations of Machine Learning ● DS Elective ● MIS 3200 Systems Analysis and Design ● GenEd Soc. And Behavioral Science ● GenEd Comm/Composition ● Co-curricular	Spring: 15.5 credits ● CS 4321 Intro to Algorithms ● DS 3401 Data Engineering ● DS elective ● MIS 3100 Business Database Mgmt. ● GenEd HUFA ● Co-curricular
Year 4	
Fall: 15 credits ● MA Elective ● DS CCE Ethics course ● DS Elective	Spring: 15 credits ● DS 4891 Capstone ● DS Elective – ML / AI ● BusTech Elective

● BusTech Elective ● Free Elective	● Free Elective ● GenEd HASS elective

12. Library and other learning resources:
No additional resources required

13. Available / Needed Equipment:
Computer lab space should suffice making use of Rekhi 112/113.

Many Data Science programs use Python as a program language, where Jupyter/Python Notebooks are the prevailing system for introducing data science concepts.[15] There are several options for running and developing these notebooks. Currently, faculty and students can use campus lab machines, free cloud services, and their own machines. JupyterHub[16] creates a multi-user Hub that spawns, manages, and proxies multiple instances of the single-user Jupyter notebook server. Use of JupyterHub is a common feature among Data Science programs for courses and research needs. A JupyterHub can be set up and maintained by IT using a local server or cloud server. Recently, organizations have offered JupyterHub as a service in the cloud. For example, 2i2c[17] is a non-profit organization that manages JupyterHub as a service for use by educational and research communities. 2i2c services include a one-time setup cost (~$1000), then monthly operations fees (~$1000/mo.) and cloud costs. [18]

Each of the options mentioned have different financial, computation resources, and personnel costs in their setup and continued management. UC Berkeley has provided several guides and documents estimating costs and describing deployment options. [19,20]

Overall, we would encourage Michigan Tech to create a common JupyterHub system for use across the data science courses as well as existing courses across campus using the service in the cloud model. This option avoids overburdening IT and can be achieved for a price that is reasonably accommodated with course lab fees.

Additionally, Git is prevalent in data science and computing. Support for a git instance (GitHub, GitLab, or other) which is managed by Michigan Tech would make it much easier for git to be integrated into the classroom and provide a safe place to store student work and research results. Currently, faculty typically rely on third-party systems not managed by MTU and must

[15] Jupyter Notebooks. https://jupyter.org/
[16] JupyterHub. https://github.com/jupyterhub/jupyterhub
[17] 2i2c. https://2i2c.org/
[18] 2i2c Service Offerings and Pricing. https://docs.google.com/document/d/1FNiDyKNDoe_TgU2WxuNZ5CayYD56tlNJpImQsAIGOmg/edit
[19] Data Science Technology Infrastructure, https://ucbds-infra.github.io/ds-course-infra-guide/intro.html
[20] Choosing the Right JupyterHub Infrastructure, https://test-data-science.pantheon.berkeley.edu/choosing-right-jupyterhub-infrastructure

collect usernames of each student if they wish to create a place where all students can interact on the same code or data.

14. Program Costs and Justifications for Years 1, 2, and 3:
With the rolling introduction of several new data science courses, as well as increased enrollment in existing high-enrollment courses (e.g., CS 1121, CS 1122, CS 2321, CS 3000, CS 4321, MA 2330, MA 2710, MA 3720, MA 4710, MA 4790, etc.), the program will require resources to meet the expected enrollment.

The program requests:

- One teaching faculty position in data science, and
- One tenure-track faculty position in data science related areas.

If enrollment exceeds projects or continues to grow additional faculty lines may be needed to meet the growing enrollment in both the College of Computing and Department of Mathematical Sciences.

Note that AI/ML (artificial intelligence and machine learning) and data science has been a major hiring priority for the College of Computing over the past several years. In fact, across our two departments, since the college was founded in 2019, we have hired seven faculty members that have the expertise to support this program. That is, the requests above continue the trajectory the college is already on and are already included in our resource planning.

15. Accreditation Requirements:
Data Science programs are now being accredited through ABET with both the Applied and Natural Science Accreditation Commission (ANSAC) and Computing Accreditation Commission (CAC). We likely intend to pursue ABET accreditation with CAC in the future.

16. Planned Implementation Date: Fall 2023

Additional Information

1. Program Administration, Policies, Regulations and Rules
The department chair of Computer Science will be responsible for administering the program in accordance with university/policy. The chair would be advised by the Director of Data Science Initiatives in the College of Computing.

2. Scheduling Plans: Regular

3. Space:
Classroom space for high enrollment courses with large sections will be further stretched or additional sections will need to be created. Computer lab space should suffice for the first few years of the program making use of Rekhi 112/113. If enrollment matches or exceeds projections, computer lab space will also begin to tighten (in particular if the university prioritizes having one of the lab classrooms to be open for all student use). Finally, space for new faculty is also tight. Note, the requested Center for Convergence and Innovation will help allay space

concerns for the future.

4. Faculty Resumes:
Available online. https://www.mtu.edu/cs/department/people/

Financial Implications

1. Relation to University Strategic Plan

a. Relation of program to the university's educational and research goals

The proposed degree in Data Science supports the University's Strategic Plan.[21] Relation to Tech Forward initiatives: (i) Education for the 21st Century; and (ii) Data Revolution and Sensing. Given the flexible and broad nature of the program, good-faith arguments can be made that it also supports the other technical initiatives, including: (i) Advanced Materials and Manufacturing; (ii) Autonomous and Intelligent Systems; (iii) Health and Quality of Life; and (iv) Natural Resources, Water and Energy.

The proposed degree also aligns with the Education Goals of the strategic plan, "*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."* The proposed degree meets the following itemized goals:

- *"Provide research, service-learning, project-based, entrepreneurial, and international opportunities for students"* Students will complete a project-based capstone course. In addition, other courses students take as electives or part of their focus area are also project-based experiences.
- *"Promote mutual appreciation of, and collaborative opportunities across, academic disciplines"* Data Science as a field is naturally interdisciplinary. Students will take courses across at least two main units computer science and mathematics and may add a third with their focus area (e.g., business, forestry, etc.).
- *"Continually assess, review, and improve programs and develop new offerings in emerging disciplinary and interdisciplinary areas"* The proposed program is a new interdisciplinary offering. We plan to develop more connections to other units on campus by adding additional focus areas as the program grows. The program is in an area of high demand and growth.

Additionally, the proposed degree provides transformative education opportunities, in particular:

- *"Foster mutual respect in personal and professional interactions"* Students will learn to work in teams with people from different backgrounds and perspectives. Project-based courses emphasize teamwork and topics from team science.
- *"Promote social and civic responsibility as well as ethical conduct."* Ethics and understanding the impact of data science tools and models is embedded

[21] MTU Strategic Plan. https://www.mtu.edu/stratplan/

throughout the curriculum and called out specifically in two core courses in the major requirements.

Finally, the program "expands programs in response to social and economic needs and challenges"; in particular:

- *"Develop and enhance pathways to completion of undergraduate and graduate programs"* The proposed curriculum includes a choice of focus area that allows students to select a pathway to complete their undergraduate degree that fits their interests. The focus area also allows students to complete a minor that complements the data science major. Additional focus areas can be designed by the student or added over time working with units across campus. Graduates of the B.S. in Data Science may elect to continue their graduate studies in several programs, including: M.S. in Computer Science, M.S. in Applied Statistics, M.S. in Cybersecurity, M.S. in Health Informatics, Ph.D. in Computer Science and Ph.D. in Computational Science and Engineering.

b. Consistency with the university's resource allocation criterion

The university's strategic plan includes growth in undergraduate enrollment (see Portrait 2045). Without question, the proposed Data Science program will help us reach that enrollment goal. The increase in enrollment will support new faculty and other resources required to maintain the proposed program.

In addition, nationally data science programs have been consistently reported to have higher enrollments among women and other underrepresented groups compared to traditional computer science and engineering programs.

2. Impact on University Enrollment

a. Projected number of students in the program

Initial enrollment projects for the program are for 20 students the first year, and 50, 85, and 125+ students over the following years. A goal of steady-state enrollment of 175-200 students is then achievable. The growth in Data Science programs across the country supports these estimates and indicates they could be exceeded.

b. Source of new students

We hope to interest new students coming to Michigan Tech, who would not otherwise enroll. We do expect the first few years of the program to potentially draw students away from the Computer Science or Mathematics programs.

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

The College of Computing is seeing increasing enrollments across the board. The Data Science program will likely contribute to further growth in that area. Demand for graduates and open jobs in this discipline are growing. While the tech industry is seeing layoffs at this time, demand for data scientists remains high with positions available

across industries (e.g., automotive, finance, healthcare, manufacturing, etc.).

d. What is the current enrollment in the unit?
Over the last three years, 2019-20, 2020-21 and 2021-22, undergraduate enrollment in Computer Science has been 519, 541, 554.

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

a. Faculty lines
The program requests one teaching faculty position and one tenure-track faculty positions in data science related areas. These requests continue the trajectory of the department and college and are included in resource planning.

b. Faculty and student labs
Currently, faculty space in Rekhi Hall is extremely tight for new faculty. We hope the space limitations will be alleviated by approval of the new Center for Convergence and Innovation. Lab space will suffice between Rekhi 112/113 with expected enrollment growth.

c. Advising
Additional advising time will be required to meet the needs for Data Science students. Advising of students will be supported by an undergraduate advisor as well as a program director to help guide students with selection of elective courses as well as selection and design of a focus area.

d. Assessment
Many of the core data science courses are already where assessment occurs for majors in computer science and/or mathematics. Additional time will be needed to enable assessment in the new data science courses as well as coordination for assessment across focus areas.

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

a. Other academic units with regards to faculty, labs and assessment
Mathematical Science will also be greatly impacted by the new degree program. Therefore, if enrollment meets projections an additional faculty line is Math is requested. In terms of assessment, the majority of the math courses required in the curriculum are also required by students majoring in math. Some additional time will be required to collect and share assessments across units.

b. Information Technology, the Library, central administration and career planning
As mentioned above in Section 13 above, support for a JupyterHub is requested. We suggest using a cloud-service for this to not burden IT resources. No additional Library and central administration resources are requested.

5. **Assessment of the ability to obtain the necessary resources assuming requested funds are obtained**
   a. **For high demand fields, will it be possible to fill allocated lines**
      Recent faculty searches in the College of Computing have been successful, therefore we believe it is realistic to fill the requested positions.

6. **Past Proposals**
   The Computer Science department has contributed to the new B.S. degree program in Mathematics and Computer Science (administratively housed in Mathematical Sciences), which started in Fall 2020. The department also participated in the creation of the B.S. in Cybersecurity, started in Fall 2019. The B.S. in Cybersecurity is interdisciplinary across the Computer Science, Applied Computing, and Electrical and Computer Engineering departments.

   a. **Describe the extent to which the new program has met the original goals**
      The table below shows enrollment in these new programs. Note, the Cybersecurity program is shared so student headcounts are shared across units.

	Fa 18	Fa 19	Fa 20	Fa 21	Fa 22
B.S. in Math and CS (SMCS)				5	9
B.S. in Cybersecurity	---	13	40	76	112
Computer Science Dept. Undergraduates	489	519	541	554	556

   b. **How have degree programs added in the past five years affected total enrollment in the department?**
      Overall, the department has seen a growth in enrollment contributed to by both the new programs and interest in computing fields.

7. **Department Budget Contribution**
   a. **What is the department's total general fund budget?**
      The computer science department's general fund budget for the academic year 2021-22 was $3,944,473. Note, this does not include lab fee revenues and learning center allocations.

   b. **How much tuition does the department generate?**
      For academic year 2021-22 (fall 2021, spring 2022, and summer 2023), the number of undergraduate student credit hours (SCH) taught by Computer Science faculty was 10,523. Because dollars per student credit hour varies by a number of factors, we use the summer tuition rate per credit hour of $629. Therefore, $6,618,967 of tuition was generated by the computer science faculty.

      For the same period, the 554 undergraduates in the computer science department enrolled in 15,372 SCHs. Using the same tuition rate, then $19,227,976 of tuition was generated by computer science students.

8. **How do the benefits from this program compare to other alternatives that are currently under consideration or development. Will approval and allocation of resources to this program preclude the development of other programs?**
   The growth in Data Science is surging across education institutes, Michigan Tech should offer a degree in this highly interdisciplinary area.