REQUEST FOR AUTHORIZATION TO IMPLEMENT A MASTER OF SCIENCE IN DATA SCIENCE AT UNIVERSITY OF WISCONSIN (UW-MILWAUKEE)PREPARED BY UW-MILWAUKEE

ABSTRACT

The University of Wisconsin-Milwaukee proposes to establish a Master of Science in Data Science (M.S. in Data Science), offered by the Graduate School. The development of this program responds to the need to prepare students for careers in data science in several fields. The program is designed so that students start with required foundations if they do not have them already (credits for courses taken as foundations however will not count towards the required total credits for the degree). They then progress through seven areas of data science (described in more detail below) each involving distinctive learning outcomes. In a unique feature of this degree, in the last of these seven areas named *Specialized Skills in Data Science for Specific Applications and Fields* students will have the opportunity to pursue analytics electives related to their primary discipline of interest via courses offered in multiple disciplines including atmospheric sciences, business, biological sciences, computer science, criminal justice, Geography, healthcare, information science, political science, and sociology, among others. In their final, eighth phase of the program, students will complete either a capstone/thesis/internship project or a exam testing their ability to apply data science techniques to real-world data.

PROGRAM IDENTIFICATION

Institution Name
University of Wisconsin-Milwaukee

Title of Proposed Program
Data Science

Degree/Major Designations
Master of Science

Mode of Delivery
Single institution
Face-to-face

Projected Enrollments and Graduates by Year Five

Projected enrollments and graduations for the program over the next five years are presented in Table 1. These projections are conservative based on enrollment trends in data

analysis courses taught in different departments and colleges at UWM from Fall '2015 to Spring Summer '2021. By the end of Year 5, we expect about 125 students to be enrolled in the program over its five years and a total of 73 students to have graduated. These projections are based on an average retention rate of 75% each year (based on data for UWM). We also assume that 95% of the 25% of students who don't continue from the academic year in which they enrolled through the end of the next academic year leave because they graduated. This results in an overall graduation rate of 68.3% among all students entering the program. Although the Graduate School does not currently have reliable overall data for graduation rates, this is consistent with their conservative estimates of master's graduation rates. Given the increasing demand for data analysts, these numbers also assume that students enrolling in this program are net additions to the campus' current total matriculants.

Table 1: Five-Year Degree Program Enrollment Projections

	Year				
Category of Students	2022	2023	2024	2025	2026
New Students	25	30	36	43	52
Continuing	0	20	40	61	83
Total Enrollment	25	50	76	104	135
Graduating		6	20	52	49
Total graduates	0	6	26	78	127

Tuition Structure

The standard tuition and fee applicable for all UWM students also apply for students enrolled in the M.S. in Data Science program. For the current academic year, residential tuition and segregated fees total $5,931.82 per semester for a full-time student enrolled in 8+ credits per semester. Of this amount, $5,350.32 is attributable to tuition. Nonresident tuition and segregated fees total $12,647.34 per semester for a full-time student enrolled in 8+ credits per semester. Of this amount, $12,065.84 is attributable to tuition. Additionally, some course delivery will be in Schools which charge 'Master's Surcharge Fees'. For example, Business Master's charges $167.71 per credit for courses taken in the Lubar School of Business.

College, School, or Functional Equivalent

Graduate School

Proposed Month and Year of Implementation

Fall 2022

DESCRIPTION OF PROGRAM

Overview of the Program

Students applying to the program are expected to have proficiency, demonstrated through coursework, exams and/or a portfolio, in the following areas: Linear Algebra (3

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credits), Multivariable Calculus (4 credits), Statistics (3 credits), and Computer Literacy (6 credits). Those without these proficiencies may be admitted when they have 6 credits or fewer of the proficiency requirements remaining to be completed, but proficiency coursework does not count towards the MS.

The degree itself consists of 30 credits in all composed of the following areas:

1. Developing insights from data, for applications (3 Credits)
2. Organizing and *maintaining* large data sets. (3 Credits)
3. Methods like AI, and Machine Learning to extract insight from Data (3 Credits)
4. Knowledge and skills for using probabilistic methods to analyze uncertainty in data and develop insights (3 credits)
5. Advanced Programming for Data Collection and Data Science (3 Credits)
6. Understand the importance of, and skills for, the ethical use of data (3 Credits)
7. Specialized Skills in Data Science for Specific Applications and Fields (12 Credits)
8. An optional capstone course/thesis/internship experience (3 credits) can be substituted for 3 of the 12 credits in area
9. Students who do not pursue the capstone course/thesis/internship experience option will also be required to pass an exam that tests their ability to develop a solution for a problem using data and data science techniques learned during the program. The specialization category allows for future implementations of dual degree programs, transcript designated concentrations, etc.

Student Learning Outcomes and Program Objectives

The core objective of the MS in Data Science is to prepare students for advanced careers in data science in multiple fields. The program is designed to allow students to progress through the seven areas mentioned above in the overview of the program. Six of the seven areas are *core areas* designed to give them skills needed to be strong and ethical data scientists. Specifically, they will (1) develop insights from data, for applications, (2) learn how to work with large data sets, (3) gain experience in advanced computer programming for data science (4) become skilled in specific areas of data science such as artificial intelligence and machine learning (5) understand how to deal with uncertainty which is an inherent characteristic of data science and (6) recognize and internalize the importance of ethical use of data and data science. First, they will gain a strong understanding of the foundations of data analytics including linear algebra, calculus, statistics, and computer programming (as mentioned above, courses taken towards building these foundations if required do not count towards the total credits required for the degree). Second, they will take courses in six core areas that represent the fundamentals of data analytics, including programming languages, databases, analytics, big data, data mining and visualization, statistics, communication, and ethics. A student can choose to reinforce the core knowledge in these key areas through a capstone course, an internship or a thesis. Enrollment in a thesis or internship is subject to the approval of the Program Director and the signature of a faculty member willing to guide the thesis or internship. Students who do not pursue the capstone course/thesis/internship option will be required to pass a Master's Comprehensive Examination. The Program Director (discussed below) will be responsible for getting the

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appropriate Comprehensive Examination written by a faculty member for the student who is taking the exam and also getting the exam graded by that faculty member. During this exam, students are given a data set and a research problem to be addressed with the data, using data science techniques. Students must submit a final report in which they use the provided data set to address the research question and demonstrate that they have developed a sufficient level of expertise to work as a data scientist. This is a take-home exam and students have seven days to complete it. Third, in a unique feature of this degree, students will have the opportunity to choose and pursue electives related to their primary discipline of interest via courses offered in multiple disciplines including anthropology, business, biological sciences, computer science, GEOGraphy and sociology among others.

The overall targeted outcome of the program is to develop graduates who will

- Apply the concepts of data science inter-disciplinarily to problems in a variety of fields and industries.
- Be equipped to pursue a data science oriented career path in the discipline that they are passionate about.
- Appreciate and abide by ethical uses of data and insights from the use of data science.

Program Requirements and Curriculum

For admission to the M.S. in Data Science program, students must meet the general requirements of admission to a graduate program at UW-Milwaukee. As stated by the Graduate School, these requirements include: (1) a baccalaureate degree, or its equivalent as determined by the UWM Center on International Education, from a regionally accredited institution, completed before the first term of enrollment in the Graduate School (2) Proficiency in the English language and (3) A minimum cumulative undergraduate grade point average (GPA) of 2.75 on a 4.0 scale, or an equivalent measure on a grading system that does not use a 4.0 scale. Students applying to the program are expected to have proficiency, demonstrated through coursework, exams or a portfolio, in the following areas: Linear Algebra (3 credits), Multivariable Calculus (4 credits), Statistics (3 credits), and Computer Literacy (6 credits). Those without these proficiencies may be admitted when they have 6 credits or fewer of the proficiency requirements remaining to be completed, but proficiency coursework does not count towards the MS.

Table 2 illustrates the program curriculum for the proposed program. The program requirements are comprised of 30 credits, of which there are 18 credits across the six core areas, 12 credits of general electives in the seventh area for *Specialized Skills in Data Science for Specific Applications and Fields* of which 3 credits may be fulfilled with a capstone course. Enrollment in an internship or thesis subject to the approval of the Program Director and the signature of a faculty member willing to guide the thesis or internship.

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Table 2: Master of Science in Data Science Program Curriculum

Developing insights from data for applications (3 Credits)

1 of the following 3 courses

ATM SCI 600	Data Analytics
INFOST 687	Data Analysis for Data Science
COMPSCI 425(G)	Introduction to Data Mining

Organizing and maintaining large data sets (3 Credits)

1 of the following 8 courses

INFOST 785	Database Management systems for information professionals
INFOST 714	Metadata
INFOST 780	XML for Libraries
INFOST 783	Information Storage and Retrieval
INFOST 691	Data Management and Curation
COMPSCI 557	Database Systems
PH 718	Data Management and Visualization in R
BUS ADM 749	Data and Information Management

AI, and Machine Learning to extract insight from Data (3 Credits)

Take 1 of the following 7 courses

INFOST 582	Introduction to Data Science
BUS ADM 795	Seminar-in-Management: Ideas & Applications of Data Science In Different Fields
COMPSCI 422G	Introduction to Artificial Intelligence
COMPSCI 710	Artificial Intelligence
COMPSCI 411G	Machine Learning and Applications
COMPSCI 711	Introduction to Machine Learning
MATH 702	Industrial MATH 2

Probabilistic methods to analyze uncertainty in data (3 credits)

1 of the following 19 courses

ATM SCI 500	Statistical Methods in Atmospheric Sciences
ATM SCI 700	Statistical Methods in Atmospheric Sciences II: Signal Detection
BUS ADM 754	Statistical Analysis
BUSMGMT 709	Predictive Analytics for Managers
BUS ADM 713	Business Forecasting Methods
BUS ADM 714	Multivariate Techniques in Mgmt Research
IND ENG 575	Design of Experiments
IND ENG 765	Operations Research Methods
SOCIOL 461G	Social Data Analysis Using Regression

SOCIOL 760	Advanced Statistical Methods in Sociology
SOCIOL 982	Advanced Quantitative Analysis
PSYCH 510G	Advanced Psychological Statistics
PSYCH 610G	Experimental Design
POL SCI 390G	Political Data Analysis
POL SCI 701	Techniques of Political Science Research
POL SCI 702	Advanced Techniques of Political Science Research
ECON 411G	Economic Forecasting Methods
ECON 413G	Statistics for Economists
ECON 513G	Introduction to Econometrics
GEOG 747	Spatial Analysis
PH 711	Intermediate Biostatistics
PH 818	"Statistical Computing (""This course will cover the theory and application of common algorithms used in statistical computing.)"
GEOG 827	Qualitative Research
COMPST 701	Mathematical & Computing Fundamentals for IT Professionals
MTHSTAT 361G	Intro Prob/Stats I
MTHSTAT 362G	Intro Prob/Stats II
MTHSTAT 563G or 763	Regression
MTHSTAT 546G or 764	Time Series Analysis
MATH 571G	Probability Models
COMPSCI 720	Computational models for decision making
MTHSTAT 761	Mathematical Statistics I
MTHSTAT 762	Mathematical Statistics II
ED PSY 724	Educational Statistical Methods II
ED PSY 820	Multiple Regression and Other General Linear Models

Advanced Programming for Data Collection and Data Science (3 Credits)

1 of the following 8 courses

BUSMGMT 744	R Programming for Business Analytics
COMPST 702	Software Development in Python
GEOG 748	ArcGIS Programming with Python
URBPLAN 794	Internet Geographic Information Systems
COMPST 751	Data Structures and Algorithms
MTHSTAT 566G or 766	Computational Statistics

Ethics (3 credits)

1 of the following 7 courses

INFOST 660	Information Policy
INFOST 661	Information Ethics

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INFOST 583	Survey of Information Security
INFOST 784	Information Security Management
INFOST 761	Information Privacy
INFOST 465G	Legal aspects of info products & services (G)
BUS ADM 743	Information Privacy, Security, and Continuity

Electives (12 credits)
Take 4 of the following 52 courses

INFOST 691	Artificial Intelligence and Disruptive Technologies
BUS ADM 741	Web Mining and Analytics
BUS ADM 812	Machine Learning for Business.
BUS ADM 813	Social Media Analytics for Business
BUS ADM 817	Connected Systems for Business
BUS ADM 742	Big Data in Business
BUS ADM 745	Artificial Intelligence for Business
BUS ADM 763	Marketing Analytics
BUS ADM 769	Database Marketing
BUS ADM 816	Business Intelligence Technologies & Solutions
COMPSCI 712	Image Processing
COMPSCI 423G	Natural Language Processing
COMPSCI 723	Natural Language Processing
COMPSCI 444G or 744	Text Retrieval
COMPSCI 469G	Security
COMPSCI 535G	Analysis of Algorithms
COMPSCI 704	Analysis of Algorithms
COMPSCI 759	Data Security
Comp Sci 725	Robot Motion Planning
Comp Sci 755	Information and Coding Theory
SOCIOL. 750	Research Methods in Sociology
SOCIOL. 752	Fundamentals of Survey Methodology
SOCIOL 952	Social Network Analysis
POL SCI392G	Survey Research
GEOG 704	Remote Sensing: Environmental and Land Use Analysis
GEOG 705	Cartography
GEOG 716	Watershed Analysis and Modeling
GEOG 726	Geographic Information Science
GEOG 804	Advanced Remote Sensing
GEOG 826	Intermediate Geographic Information Science
GEOG 834	GIS and Society
GEOG 904	Remote Sensing and Urban Analysis
GEOG 926	Advanced Geographic Information Science: Geographic Modeling
GEOG 960	Seminar: Geographic Techniques
GEOG 999	Independent Work (with appropriate topic)
URBPLAN 692	Special Topics in Urban Planning: Transportation Planning and GIS
PH 812	Statistical Learning and Data Mining
URBPLAN 791	Introduction to Urban Geographic Information Systems for Planning
URBPLAN 792	Using Urban Geographic Information Systems for Planning

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URBPLAN 999	Independent Study
ANTHRO 380	Anthropological Applications of GIS
ANTHRO 562	Techniques and Problems in Archaeology
ANTHO 768	Topics in Advanced Research Design in Anthropology
CRM JST 520G	Analysis Oriented Technology: Spatial Data Analysis; Crime Mapping; ArcGIS
CRM JST 713	Measuring Crime & Analyzing Crime Data
CRM JST 716	Advanced Analytic Techniques for Crime Analysts
CRM JST 910	Methods and Practice Capstone for Crime Analysts
ART 526G	Research in Universal Design and Fabrication
ART 316 G	Interactive and Multimedia Art
ART 317 G	3D Imaging I
ART 427 U/G	Special Topics Course
ART 313 U/G	Interactive and Multimedia Art and Programming for Artists
ED PSY 720	Techniques of Educational and Psychological Measurement
MATH 701	Industrial MATH 1
ED PSY 821	Psychometric Theory and Practice
ED PSY 822	Modern Test Theory
ED PSY 823	Structural Equation Modeling
ED PSY 824	Advanced Experimental Design and Analysis
ED PSY 825	Multivariate Methods
ED PSY 826	Analysis of Cross-Classified Categorical Data
ED PSY 827	Survey Research Methods in Education
ED PSY 832	Theory of Hierarchical Linear Modeling
BIO SCI 469	Genomic Data Analysis
BIO SCI 502	Introduction to Programming and Modeling in Ecology and Evolution
BIO SCI 572	Functional Genomics

* Every student's program of electives must be approved by the program director; students may be able to count as Electives some courses in the "core" categories not applied to the core requirements (subject to Director's approval). Students wishing to apply other courses not listed here towards these electives must have each course approved by the program director

Optional: Internship/Thesis/Capstone
Of the required 12 elective credits, up to 3 degree credits may be awarded for a thesis or internship. Students who choose this option must complete a relevant thesis or internship that is approved by the program director. Students who choose to complete a thesis must work with a thesis advisor and have the thesis approved by the advisor and the program director. Students who choose to pursue an internship must also obtain approval from the program director. Students may select from courses such as those listed below or enroll for thesis credits with their thesis advisor (in the advisor's department).

INFOST 790	Project Design, Implementation, and Evaluation
GEOG 798	GIS/Cartography Internship
URBPLAN 793	Applied Projects in Urban Geographic Information Systems
URBPLAN 991	Legislative/Administrative Agency Internship
MATH 790	Master's Thesis
COMPSCI 990	Master's Thesis

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COMPSCI 995 Master's Capstone Project
Qualifying Exam

Students who do not choose to pursue the optional capstone course/thesis/internship option are required to pass a qualifying exam. During this exam, students are given a data set and a research problem to be addressed with the data, using data science techniques. Students must submit a final report in which they use the provided data set to address the research question and demonstrate that they have developed a sufficient level of expertise to work as a data scientist. This is a take-home exam and students have seven days to complete it.

Assessment of Outcomes and Objectives

As mentioned above, all students will need to either pursue the optional capstone course/thesis/internship option or take a qualifying exam to complete the requirements of the degree. Performance in the capstone course/thesis/internship or the qualifying exam will serve as the primary vehicle for the assessment of outcomes and objectives. In addition, As is the case with all advanced degrees at UWM, the program will go through a campus-coordinated assessment exercise required for Higher Learning Commission (HLC) accreditation. Courses in several of the participating colleges and departments also go through their own accreditation periodically. For example, courses in Computer Science are regularly assessed as part of the Accreditation Board for Engineering and Technology (ABET) accreditation process. Similarly, degrees in the Lubar School of Business go through an accreditation process by American Association of Collegiate Schools of Business (AACSB) and hence courses in the degrees that are part of the proposed degree will also be assessed. A specific assessment of the learning outcomes and objectives of the M.S. in Data Science program will also be conducted by regularly surveying graduates of the program.

Diversity

The M.S. in Data Science program seeks to prepare students from diverse backgrounds by providing them the expertise to gain employment in the rapidly growing job markets for data science. This will therefore result in an increase in the participation of women and minorities in the programs. Additionally, 35% of undergraduate students at UWM are first-generation students and 32% are students of color. By providing them the opportunity to continue on after completing their undergraduate studies at the university, the proposed program will serve their higher education needs and thus serve these diverse student populations. The program's curriculum also includes several courses that will provide students several opportunities to learn about, and practice, the importance of diversity of people, points of view, and theoretical perspectives through the required Ethics components of curriculum.

Program Review

Consistent with the policies and procedures of the University of Wisconsin-Milwaukee, the proposed program will be reviewed by a faculty oversight committee (FOC) every five years to ensure that the degree continuously meets the needs of

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students and employers. The FOC will also be responsible for governance of the degree. The degree will be managed by a Program Director who will be appointed by the FOC.

Rationale and Relation to Mission

The UW-Milwaukee Select Mission Statement (https://uwm.edu/mission/) states:

"To fulfill its mission as a major urban doctoral university and to meet the diverse needs of Wisconsin's largest metropolitan area, the University of Wisconsin-Milwaukee must provide a wide array of degree programs, a balanced program of applied and basic research, and a faculty who are active in public service. Fulfilling this mission requires the pursuit of these mutually reinforcing academic goals". Among the several goals listed in this statement, the MSDS program especially contributes to the following:

- "To further academic and professional opportunities at all levels for women, minority, part-time, and financially or educationally disadvantaged students.
- To establish and maintain productive relationships with appropriate public and private organizations at the local, regional, state, national, and international levels.
- To promote public service and research efforts directed toward meeting the social, Economic and cultural needs of the state of Wisconsin and its metropolitan areas.
- To provide educational leadership in meeting future social, cultural, and technological challenges."

Given the rapid and continuing growth in the use of data science across all sectors of public and private activities, the proposed degree with increase professional opportunities for all students that enroll in the program and especially disadvantaged students by providing them with highly sought skills and training. This, in turn, will expand and strengthen UWM's relationships with both public and private organizations that are in need of the skills. Additionally, graduates of the program will be well-trained to support research using data science where needed and help their employers meet the technological challenges and opportunities presented by the growing use of vast amounts of data in every sector of society.

Other Programs in the University of Wisconsin System

There is only one Master's degree in Data Science currently being offered through the UW Data Science Collaborative program at UW- Eau Claire, UW-Green Bay, and UW-La Crosse. The degree however focuses on different areas of data science like data mining and visualization and does not include applications to specific disciplines. On the other hand, our program aims to provide multi and inter-disciplinary training. Such training is increasingly sought by employers and advocated by scholars. A workshop convened by the National Research Council's *Committee on Applied and Theoretical Statistics; Board on Mathematical Sciences and Their Applications; Division on Engineering and Physical Sciences* (https://www.ncbi.nlm.nih.gov/books/NBK299101/) recommends that academic data science and data analytics programs should be designed to be inter-disciplinary all through and also foster collaborative skills. This proposed program is thus designed to be consistent with employer needs and recommendations by national scholars and also does not create unnecessary duplication.

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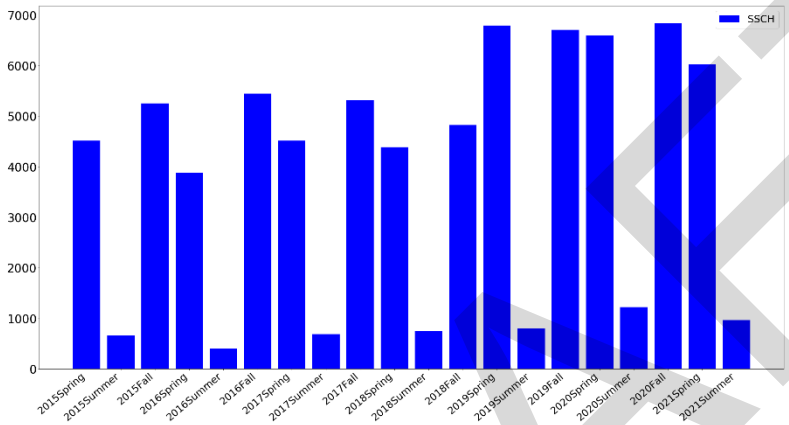
(https://www.ncbi.nlm.nih.gov/books/NBK299101/) recommends that academic data science and data analytics programs should be designed to be inter-disciplinary all through and also foster collaborative skills.

Need as Suggested by Current Student Demand

We have been tracking student enrollment in 140 courses on our campus identified as imparting skills related to data analytics. The chart below shows the average enrollments in these classes, in terms of average total student credit hours per class, during each semester since 2015. As demonstrated by the chart, there has been a significant increase since 2019 in student interest in these classes.



Need as Suggested by Market Demand

A report from the employment outlook firm Burning Glass produced jointly with IBM and the Business Higher Education Forum identified several job categories in the data science and analytics field, including data driven decision makers ("leverage data to inform strategic and operational decisions") and functional analysts ("utilize data and analytical models to inform specific functions and business decisions"). They estimated a national demand of 1.8 million job postings nationwide for 2020, with a 5-year growth rate of approximately 15%. Importantly, the report also states: "39% of Data Scientists and Advanced Analysts require a Master's or Ph.D. These degrees take additional years of schooling to complete, so it will take a significant time investment to train a larger pool of workers. Therefore, because these roles are already undersupplied and projected to grow rapidly, the skills shortage is in danger of worsening."

The Bureau of Labor Statistics (https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm) also projects that *Computer and Information Research Scientists* category of jobs will grow 15% over the 2019-2029 period and describes this as: "…much faster than average for all occupations. Job prospects are expected to be excellent" and states that the "median annual wage for computer and information research scientists was $126,830 in May 2020." BLS also classifies this as a category in which most jobs require a Master's degree.

Additional evidence of demand is also seen in investments made by employers like Northwestern Mutual that have invested significant resources of $15 million in the

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establishment of the Northwestern Mutual Data Science Institute to support the launch and growth of undergraduate and graduate programs related to data including data science and data analytics.

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