

Overview

The major paradigms for scientific inquiry until the 1960s were empirical and theoretical. Computation/simulation and data science have emerged as two new paradigms for scientific inquiry.¹ In recent years, there have been many disruptive applications of computation and data science such as massively parallel computing and machine learning that have greatly advanced science and technology and spurred on tremendous economic growth. There is also a corresponding rising interest in the theoretical underpinnings of the field of data science.² UW has the opportunity to become one of the leading land-grant institutions that provides its students with the knowledge and experience to utilize each of these paradigms of inquiry. The department of Mathematics and Statistics, with the proper support, is well-positioned to contribute to three of these levels of inquiry, namely computation and simulation, data science, and theory.

The department has long-standing strengths in applied mathematics, especially in high-performance computing and numerical modeling. It also has strengths in algebra and combinatorics, statistics, and analysis. The analysis and algebra groups are more theoretical, and the applied mathematics and statistics groups are more computational. Notably, all four research groups in the department feature expertise that is fundamental to modern data science and deep learning. These strategically chosen areas of expertise also promote active collaborations with other UW units, notably in Geology & Geophysics, the College of Engineering and Applied Science, and the School of Energy Resources. One Math/Stats faculty member holds a SER appointment, and another Math/Stats faculty member holds a joint appointment with Zoology & Physiology.

Our department is both a high credit hour producing department with many service courses for other departments as well as a research focused department. We have a strong record of award-winning teaching, research and service³ to the University at large. As such, an investment in Math/Stat will pay multiple dividends. Below, we outline ways that we do contribute and can contribute in the future to UW's mission.

Reasons for Investment (from given template list)

- **Market demand for graduates of unit's programs (using Gray's data or other relevant data considering typical jobs degree holders work in)**

Gray and Associates gathered data on programs with a CIP code and ranked them according to various criteria including IPEDs data⁴, google searches, and data from

¹ Hey, Tony, Tansley, Stewart, and Tolle, Kristin, *The Forth Paradigm, Data-Intensive Scientific Discovery*, Microsoft Corporation 2009.

² See https://www.nsf.gov/awardsearch/showAward?AWD_ID=2023528&HistoricalAwards=false

³ See "awardsummary.docx", included with this report

⁴ See <https://nces.ed.gov/ipeds/use-the-data>

the Bureau of Labor Statistics. These were compared with programs nationally and with programs geographically located within 360 miles of Laramie. Their analysis ranks the following degrees in our program highly: Statistics Bachelors (nationally) 94 percentile, Statistics Masters (nationally) 91 percentile, Statistics Bachelors (Laramie 360) 93 percentile, Statistics Masters (Laramie 360) 86 percentile, Mathematics Bachelors (nationally) 98 percentile, Mathematics Masters (nationally) 98 percentile, Mathematics PhD (nationally) 96 percentile, Mathematics Bachelors (Laramie) 98 percentile, Mathematics Masters (Laramie 360) 93 percentile, Mathematics PhD (Laramie 360) 95 percentile. In particular, the projected 10-year growth was in the 90-100 percentile in all of the above programs. The Gray data scorecards are included with this report. Gray and Associates does not have scorecards for Data Science as it did not have a CIP code at the time of their analysis.

· **Present and probable future demand justifies current or increasing levels of support. Indications of significant increase in one or more areas over 5 years.**

The rising demand of data science is well documented. Indeed, it is projected that “nearly 70% of business leaders in the United States will prefer job applicants with data skills by 2021.”⁵ The Gray data analysis puts the predicted 10-year growth for the aforementioned degree programs in math and stat consistently in the 90th percentile and above.

· **In case of instructional-focused programs, level of demand by other departments and by student interest for the courses provided.**

The Department of Mathematics and Statistics teaches a large number of courses for engineering and sciences, including Statistics graduate classes for other graduate programs in the sciences. There were 24570 SCH of Math and Statistics courses taught this past year, 91.6% of which were to non-majors.⁶ See attached document “NonmajorOutreach.xlsx”⁷ for breakdowns of percentages of SCH taught in other disciplines. Within the University, there is a rising need for data science within all disciplines and, thus, a need for expertise that currently exists within Math/Stat. With the appropriate hires, this course list can be expanded for service courses to other disciplines.

· **In case of research-focused programs, quality and quantity of research, scholarly, and creative work produced.**

Our tenured/tenure track faculty produced 154 refereed publications in mathematics and statistics in the years of 2017-2019,⁸ with an average of roughly 2.4 per year per tenured/tenure track faculty. Our expectations for 27.5% research (the standard percentage) are an average of 1 publication per year. Some of these publications were quite lengthy, including a book and an individual paper of well over 50 pages

⁵ See <https://www.amstat.org/asa/News/New-Report-Highlights-Growing-Demand-for-Data-Science-Analytics-Talent.aspx>

⁶ See “math and statistics sch.xlsx”, included with this report

⁷ See “NonmajorOutreach.xlsx”, included with this report

⁸ From annual updates, years 2017,2018, 2019.

published in a high-quality journal. Our faculty reported 152 talks over that time period⁹, with an average of 2.3 talks per year per tenured/tenure track faculty member.

· **In case of research-focused programs, level of external funding relative to availability of funding in the field.**

Unlike some fields in which grant funding is necessary to carry out any research, mathematics and statistics research can be done in the absence of funding. As such, funding is generally smaller than lab sciences and grants are difficult to obtain. Math/Stat Department members currently hold 15 active research grants as either PI or co-PI.¹⁰ Furthermore, each one of our four research groups has at least one person who is a PI on a grant supporting his/her research.

· **Strength of international or national reputation, regional strength, and/or state service is high.**

The vast majority of math and stat instructors at Wyoming's community colleges are trained in UW programs. It will be incumbent on our department to help develop the data science, computing, math and stat curricula at these institutions. All UW Math Education majors complete a concurrent Mathematics BA/BS degree, and elementary education teachers take math courses taught from our department, which means we also train many future K-12 teachers.

· **Productivity of program in absolute terms or relative to the university's investment in faculty, staff, equipment, facilities, or other resources is high or has increased significantly.**

Arts and Sciences generated 153,719 SCH¹¹ with 354.25 total faculty¹².

Mathematics and Statistics has 29 (approximately 8.2%) of the A&S faculty, but generates 24570 (approximately 16%) of the SCH.

· **The unit's programs will demonstrably contribute to UW's strategic vision.**

The University's strategic plan is directed toward "Graduate students who have experienced the frontiers of scholarship and creative activity and who are prepared for the complexities of an interdependent world".¹³ Data Science and interdisciplinarity is now a big part of these frontiers. The goal to "Hire strategically to ensure robust disciplinary and interdisciplinary scholarship and to support academic and co-curricular opportunities that meet the needs of 21st century students" is a large part of our proposal below.

· **The unit's program reflects what land grant universities typically offer.**

Mathematics and Statistics degrees are ubiquitous in Land grant Universities. The land grant mission of the University of Wyoming states: "We honor our heritage as the state's flagship and land-grant university by providing accessible and affordable

⁹ From annual updates. Number of talks under-reported in 2019 due to apparent confusion with the new system.

¹⁰ See "Grant.xlsx", included with this report

¹¹ See "SCH_Comparisons_by_College.xlsx", included with this report

¹² See "OIA.Fall19.2020Sep16.xlsx", included with this report

¹³ Breaking Through 2017-2022: A Strategic Plan for the University of Wyoming.

higher education of the highest quality; rigorous scholarship; the communication and application of knowledge; economic and community development; and responsible stewardship of our cultural, historical and natural resources.”

Modern mathematics and statistics applications span all areas of our society – economic and community development, healthcare, business, education, cultural and historical preservation, use of natural resources, etc. – and, therefore, lies at the heart of our land grant mission. This interconnectivity echoes the land grant mission of the University of Wyoming.¹⁴

· **Eminent faculty members of the unit stand out in national recognition.**

Stefan Heinz was recently named an Associate Fellow of the National Society of Aeronautics. Craig Douglas is an internationally known expert in high performance computing and big data, and holds a SER distinguished professorship. Zhuang Niu won the Israel Halperin prize in Operator Algebras in 2015. Bryan Shader is the editor and Chief of the *Electronic Journal of Linear Algebra*, Associate editor for *Linear Algebra and its Applications*, and *Linear and Multilinear Algebra*. Tim Robinson is a Fellow of the American Statistical Association and of the American Society for Quality, and serves as an Associated Editor for three journals: *Journal of Statistics and Data Science Education*; *Quality Engineering*; and *Quality & Reliability Engineering International*.

· **President Seidel has identified the themes of more digital, more entrepreneurial, more interdisciplinary and more inclusive to embed across all UW programs. What is the role of these themes in this program?**

Mathematics and Statistics have large roles in computation/simulation and data science. The department already has a large number of faculty who provide modeling or statistical analysis to other programs such as Petroleum Engineering, Biology, Engineering. The department’s active grants cover many interdisciplinary topics such as genomics, turbulence, ecology, and zoology. The Math/Stat department will be a leader in the provision of data science services (ex. Modeling and analysis of big data, software training, data management, etc.) both within the University and externally. Through mathematical and statistical modeling, its collaboration with a new center for computation (see below) and targeted hires will support and engage in further interdisciplinary collaborations. In terms of inclusivity, we note that the mathematics graduate program recruited an incoming class of seven students in 2018 that consisted of five women, one of whom was African American, one African male, and one Vietnamese male. With added resources and focused recruiting, we will strive to replicate and extend this success. In support of the entrepreneurial pillar, we would extend our online offerings and our list of classes (see next page).

¹⁴ See <http://www.uwyo.edu/acadaffairs/mission/>

Recommendations:

For the last decade, the department has been significantly shrinking due to budgetary constraints on the university. This has reduced our capacity for experimental courses as well as sabbaticals, and has increased teaching loads. Consequently, grant funding and new course and program generation has also declined. Among our losses are some of our award-winning teachers and researchers, notably Greg Lyng, Farhad Jafari, and Myron Allen, without replacements. A larger pool of research-active faculty will result in greater grant funding and more expertise to run a variety of classes and will expand our programs to fill the needs of a more quantitative, computational and data driven society. We recommend at least 10 hires for the department over the next three years, hiring in multiple areas of mathematics and statistics, with computation and interdisciplinarity as a common thread among these hires. Some of these would be targeting joint appointments with other departments. Two or three of these hires can be recurring two-year visiting professorships targeted to new PhDs. These visiting professorships will bring in a steady stream of new ideas and expertise while over time creating links between our department with the universities or businesses they are ultimately hired in.

Some benefits of a larger pool of faculty include: the ability to run 1-2 week training courses and workshops; the development of online courses and programs; the greater ability to work with other departments and serve on thesis committees; the ability to designate faculty liaisons to other departments; the development of courses for in-service and pre-service teachers of modern mathematics and data science (i.e. K-12 teachers); the development of courses to expose undergraduates to principles of modern mathematics and data science; the conversion of degree programs to be offered online; and the support and co-development of joint/interdisciplinary graduate programs and minors.

To support interdisciplinary research, the department would also play a critical role in the establishment and success of a Center for Computation and Technology in the spirit of what currently exists at LSU (<https://www.cct.lsu.edu/about>). The mission of this unit is as follows: "The Center for Computation & Technology at Louisiana State University is an innovative and interdisciplinary research environment, advancing computational sciences, technologies, and the disciplines they touch." The Center serves Louisiana through international collaboration, leading progress through revolutionary advancement in academia and industry. Through strategic hires (ex. expertise in cyberinfrastructure, data science, etc.), our department will be instrumental in supporting a similar center. In coordination with this center, we will enable quantitative education and research within the University and the State of Wyoming.

To achieve these goals, we also require 5 additional GA/RAs, 3 in math and 2 in stat to bolster the graduate programs of the department and provide teaching/research support as we enhance the curriculum around our new hires. These will be for a 5-year period with the aim of ultimately replacing them with grant funded graduate students.