THE UNIVERSITY OF
MAINE
Graduate School

Graduate Board
Room 57, Stodder Hall
Thursday, April 25, 2019
3:00 pm – refreshments
3:15 pm - meeting

<u>AGENDA</u>

1. Review/approval of the February 28, 2019 Graduate Board minutes

2. Review/approval of the March 5 and April 9, 2019 Curriculum Committee reports

3. Announcements/updates:
   - 3MT competition finals
   - UMSS feedback
   - NAS visit (May 21-22); See: https://umaine.edu/risingtide/conversations-for-change/
   - Graduate Commencement
   - Holistic application review

4. Review of proposed 4+1 track in Special Education (High Incidence Disabilities)

5. Review of proposal for a MS in Data Science and Engineering – Penny Rheingans

6. Strategic Vision and Values: Summary of March 8 Graduate Summit discussion
   See: https://umaine.edu/strategic-visioning/graduate-education-summit/

7. Items arising

Graduate Board
Room 57, Stodder Hall
Thursday, February 28, 2019
3:00 pm – refreshments
3:15 pm – meeting

25 In Attendance: R. Borgman (on behalf of P. Agrrawal), J. Artesani, K. Beard, J.Bomar, D. Bousfield, T. Bowden, S. Butler, S. Delcourt, D. Dryer, S. Ell, K. Evans, J. Ferland, C. Grindrod, S. Jain, M. Larocque, I Mette, S. Ohno, E. Pandiscio, A. Reeve, L. Rickard, C. Sponarsky, M. Tajvidi, K. Varahramyan, K. Vekasi, V. Weaver

Guest: President Joan Ferrini-Mundy; Jason Charland

Minutes

1. Review/approval of the January 31, 2019 Graduate Board minutes
   Dylan Dryer – moved to approve minutes
   Unanimous approval with 1 – abstention – J. Ferland

2. Review/approval of the February 12, 2019 Curriculum Committee report

   Courses reviewed on January 22, 2019, but needing revisions:
   > BEN 502 – Advanced Materials in Bio-Inspired Engineering
   > BEN 503 – Advanced Instrumental Design
   > BEN 512 – Modeling of Biomedical Systems
   > BEN 580 – Computational Methods in Biomedical Engineering
   > BMB 520 – Introduction to Image Analysis
   > EDT 532 – Instructional Technology – Creative and Connective Learning Environments

   February 12, 2019 - Curriculum Committee Meeting – 2 New Courses Presented:
   > PSY 581 –Supervision, Consultation in Interprofessional Issues
   > BMS605 – Professionalism and Responsible Conduct in Biomedical Science and Engineering.

Modifications to communication sciences and disorders graduate courses
– addition of prerequisite to be enrolled and matriculated in the graduate program in CSD

3 Modifications to Food Science and Nutrition:
FSN 501 – Advanced Human Nutrition
FSN 530 – Integrative and Functional Nutrition
FSN 603 – Nutrients and Food Processing

Motion to accept the Curriculum Committee report– Sandy Butler
Discussion / Concerns –none
Unanimous approval

3. Announcements

- Enrollment management update – very good at this point
  +6% from last year in applications & 1% from year prior.
  +56% confirmations from last year and 151% from the year prior.
  Doctoral applications are up 20% from last year and 33% from the year prior.

  Some of the increase in doctoral applications is due to the PhD in Biomedical Science and Biomedical Engineering – Doctoral applications +50% from previous years in this program – very strong
  Graduate School did some enhanced recruiting for GSBSE this year.

  Announcement – Jamie Ballinger has left the Graduate School to take a new position as Director of Graduate programs for the University of Maine Graduate School of Business.

- Judges needed for UMSS (April 10)
  Elisabeth Kilroy & S. Delcourt are co-chairing the UMSS committee – there is a link where you can volunteer to be a judge.
  There is a current motion to declare an academic day – it is is currently pending. We can send the link to all members after this.

  Mug Club (UMaine Grad School in partnership with the GSG – part of the UMaineGRAD program for professional development)
  – launched last month – 1st event was a great success
  Attendees are provided with travel coffee mugs with "Mug Club" stickers.
  February event was a service event – Valentine's Cards for Veterans Homes
  Upcoming Events – March 7 Event – Thesis formatting and submission
  April – Networking and interviewing (panel of area professionals)
  May - Maine Day event
  June - Financial Responsibility focus

M. Larocque – asked about bringing undergrads / grads together – looking for clarity on the audience. S. Delcourt noted that undergrads are included to begin socializing them to graduate school. M. Larocque mentioned that we should explain purpose(s) of the meetings to avoid confusion.
Events will be recorded for online students & those who cannot make it.

- Shared TAs selected – Debbi Clements sent out an announcement on this. S. Delcourt noted that if programs have students in need of an assistantship who are qualified to teach introductory BIO, CHY, PHY or MAT, please nominate them and we will fill positions as they become available.
  Alternates are also important – students could move up the list as students receive alternative offers.

- Graduate Summit March 8; 8:30-11:30am
  RSVP by March 1: https://goo.gl/forms/3d0gfcLEI51XqecZ2
  59 people have now responded. 47 people have now signed up. There is room for more. M. Larocque needs to know by the end of the day tomorrow.
  S. Delcourt - 3 hours discussion of various aspects of graduate education (both master's and doctoral degree programs).
  S. Jain noted that the time of the Summit is prime teaching time – and asked if Scott would be able to relay what was discussed at the summit to the Graduate Board.
  M. Larocque will get an agenda out by Monday or Tuesday at the latest.

- The Graduate School Commencement Ceremony Friday, May 10; 4-6pm
  Doug Hall will be our speaker.
  Reception following in Well Conference Centers.

4. Visit by President Ferrini-Mundy
   Vice President and Dean Varahramyan introduced President Ferrini-Mundy
   Graduate Board members introduced themselves.

   President Ferrini-Mundy mentioned that Jason Charland would assist her in the presentation.
   Quick Introduction – UMS – Board of Trustees – Declaration of Strategic Priorities (. Vision for UMS going forward. One of the strategic priorities pertained to research, and President Ferrini-Mundy was charged with developing a research plan for UMS.

   Focus will be on advancing workforce readiness & economic development

   Deliverable – multi-year plan for prioritizing and expanded research
   We are in the middle of developing the plan now.

This has been an inclusive process. Different groups of researchers – and many open discussions with University stakeholders such as the Graduate Board. The plan's focus on the economy of Maine is not a new topic or a surprise. We are funded in great part by the state, but the percentage is less every year. How do we strengthen and grow?

MEIF – came about through the efforts of UMaine faculty. We need a research university to be properly funded. MEIF dollars were put in place. What was the impact of that funding and influence on the economy?

Development – Basic Research, Applied Research, Experimental Development. As you might expect – this effort is centered on people. We need the thinkers, the scholars, the post-docs, the staff – all working together to move the University's research mission forward.

HERD survey– indicators made public every other year. Research that brings in external dollars. UNH – now in the research 1 category, UMaine – research 2 We need to track our data better since better reporting relates to university classification.

University expenditures - we don't always spend down every grant that we get – and we don't always spend them on time. This is an important consideration in HERD also.

UMS R&D Plan Steering Committee – is open to everyone to provide input. We are not looking to report on every single recommendation that gets made – but to report on the organization as a whole. Best way is to let Jason know if you wish to read and comment and critique on some material if you have time for that.

Proposed set of 3 goals –

1. Make the state of Maine the most desirable state in the nation by 2030.
2. Enhance Maine's economic viability by increasing capacity across all sectors statewide to invest in R&D.
3. Generate the knowledge-growing workforce required for Maine's future, expanded R&D enterprise and innovation economy.

Forest biomass, K-12 education and many other topics.

How do we work on #1 – how do we make Maine more desirable vs. other states in the nation? General goal – it has elements about technology, quality of life, the arts, etc… things that we as a University wish to engage in.

The state's capacity to invest in R&D has an impact. Maine ranks 52nd (including US Territories – Virgin Islands, etc…) in overall spending in R&D. We are not a

heavy R&D state – in part because our industry does not require R&D. This may indicate our ability to draw people to the state. We want to do what we can to bring this number up – and do better.

Milestones – under goal #2 – leadership asking about research focus.
MEIF includes a list of 7 technology sectors – that is where those MEIF funds are supposed to go. We are already narrowing what's open for investment. Parts of our University are seen as open and available and other parts are not. Suggestions on this would be welcome.

Perception that there is not much research going on at other UMS campuses – and that is absolutely not true. We can benefit from working with them and their communities greatly.

In the 3rd goal, we are trying to make some points about the work force and improving the work force for Maine's economy. Maine's knowledge growing workforce is required for economic development. This goes beyond students working in labs.

President Ferrini-Mundy - I am very interested in your comments, ideas, and ways in which you'd like to be involved.

Kristen Vekasi - What's a more comprehensive way to look at outcomes and outputs?

What are ways in which faculty can help generate this information?
J. Charland – the number of grad students we are able to provide – and the number of people we are able to add to the workforce.
Disseminating information. People don't know what the University is doing – we could better communicate.

President Ferrini-Mundy – relates this to our own ability to re-think & re-configure our graduate programs. How to attract students, how to help students be successful. We need interdisciplinary teams to tackle grand challenges.

President Ferrini-Mundy – Experimental Development – production toward new processes, development. Work that is taking us back toward what is good for the State. Enlarging the research capacity for what is good for our state. USM is doing this in their talk about their role in public policy.

S. Delcourt – structure of graduate education – particularly doctoral education? Large-scale structural changes as Michael Crowe has done at ASU vs focus on cross-departmental research centers to undertake interdisciplinary research. In your time as NSF is there any sense for a preferred model?

President Ferrini-Mundy – NSF is very interested in integration across disciplines.

What does it take to do the science of tomorrow? Interdisciplinary, Convergent, Serious engagement of what needs to happen for tomorrow. Shared data sets. What is the place of disciplinary integration? NSF wants graduate education to be ready to make changes.

S. Delcourt – IPhD – and the bylaws that allow for the formation of interdisciplinary faculty groups. It may take months or years to develop a new PhD programs – but the IPhD allows us to be more nimble.
Shared TA's also help with this by providing assistantship funding across departmental boundaries.

President – Ferrini-Mundy shared resources and unexpected pairings of resources are where we should be thinking and being creative. Take what is already a forward looking idea to the next level.

Provide comments to this web-site or email Jason Charland directly.

Eric Pandiscio: Regarding the desirability of states – where are we now? What aspects of the R&D align with characteristics that make a state desirable?
J. Charland: how can we attract talent to the state? How do we drive people here?

President Ferrini-Mundy – We need solid ideas on how our state could improve. How could K-12 be amenable to R&D?

5. Review of 2 graduate certificates – one in Human Nutrition and one in Food Technology
    Courses that could be offered around the state – approximately 18 credit certificates. Within the planned Master's program – students specialize in either Food Technology or Nutrition.
    If approved, the online courses comprising the 2 certificates will be developed in UMaineGOLD round 2.
    Motion to approve – Stom Ohno
    Mehdi Tajvidi – wishes them good luck.
    All in favor – unanimous.

6. Items arising:

    Jacques Ferland - Addressing our critical state needs….it is very subjective and difficult to plan more than a few years out. Present needs are nurses in our state. Will that still be our need in 2030? I was not very convinced that we can project that far in advance.

    S. Delcourt – if we had a way to project – or a crystal ball. Graduate program needs will be projected based on employment data. For example, many faculty

positions will become open – there will be a lot of faculty members retiring in the next 10-15 years.

Link for Graduate Summit will be sent out by Monique.

S. Delcourt will send the link for volunteering at the UMaine Student Symposium

Meeting Adjourned at 4:29pm

CURRICULUM COMMITTEE REPORT

The Curriculum Committee met on April 9th, 2019 and recommends the following courses to the Graduate Board for approval at its April 25th, 2019 meeting.

New Courses:

FSN 580 Food Chemistry

AVS 555 Animal Nutrition

AVS 556 Animal Nutrition Laboratory

COS 565 Data Visualization

The following new courses were considered by the Curriculum Committee in March but were not reviewed by Graduate Board due to a meeting cancellation. These courses are now ready for approval.

New Courses:

CIE 559 Marine Turbulence

BUA 670 Managerial Marketing

Proposal for 4+1 in High Incidence Disabilities
University of Maine and University of Maine at Machias

This partnership will allow both UM and UMM students to articulate into a 4+1 program at UM to earn a Master's degree in High Incidence Disabilities. Twelve credits, taken at the 400 level through UMM can articulate into the M.Ed. at the University of Maine.

A feeder program for this program exists through a second partnership between UM and UMM. Elementary Education students at UM must complete an 18 credit area of specialization. One such specialization is in the area of Special Education whereby UM students complete one course at UM and 5 at UMM in Special Education. Students majoring in Special Education at UMM take all of the courses included in the partnership agreement as part of their programs, including the 12 credits we propose to bring into a 4+1 agreement.

The required courses in the Area of Specialization are at the 400 level (with 500 level course options available at UM). These 4 courses (12 CH) may be counted as part of 4+1 programs for students whose Area of Specialization is Special Education and who apply to the 4+1 program in Special Education.

Required Courses in the Area of Specialization
SED 302: Adapting Instruction for Students with Disabilities
SED 425 Assessment (articulating as SED 553 UM)
SED 435 Program Planning (articulating as SED 543 at UM
SED 420 Special Education Law (articulating as SED 5 at UM)
SED 355 Transition Issues for Students with Disabilities (*This course will be revised and re-numbered at UMM to a 400-level course)

Plus, one elective from:
      SED 340 Communication & Collaboration in Special Education
      SED 362 Typical and Atypical Expressive and Receptive Language
      SED 380 Teaching Students with Autism Spectrum Disorders
      SED 330 Math in Special Education
      SED 340: Communication and collaboration in Special Education
      SED 362 Typical and Atypical expressive language
      SED 365: Differentiated instructional strategies
      SED 370: Teaching reading and writing to children with Special Needs

The undergraduate Elementary Education program at the University of Maine currently has 208 majors and UMM enrolls approximately 20 students in their Special Education undergraduate (through the Bachelor of College Studies degree) and approximately 30 post-baccalaureate special education certificate students matriculated into the program. Additionally, UMM offers a concentration in special

education for its elementary and secondary education majors. Special education is an area of high need in Maine. Employment opportunities for completers of this 4+1 program are very high. Out of necessity, many Maine schools have hired minimally-qualified special education teachers with the expectation that they become fully certified within a period of time. This flexibility in hiring less-than-qualified teachers will come to an end in 2018, with changes to Maine Rule Chapter 115, and special education teachers will need to follow a more stringent route to full teacher certification. As such, the timing for this collaboration couldn't be better.

The 4+1 Master's degree program in Special Education will allow students enrolled in UMaine's Elementary Education degree program with an Area of Specialization (18 credits) in Special Education to earn their undergraduate *and* graduate degree (including certifications in Elementary Education and Special Education/high incidence) in five years. This program will enable students enrolled in the bachelor's degree in elementary education program with an area of specialization in special education to apply for admission to the 4+1 program at candidacy, then articulate 12 CH of 400- or 500- level coursework in special education into their master's degree in special education/high incidence. Students who have applied to the 4+1 program may be able to take courses at UMM or UM to fulfill the courses within their area of specialization. Application to the 4+1 program necessitates a willingness to attend the +1 year as a full-time student.

4+1 UMaine Elementary Education students with Area of Specialization in Special Education

DEGREE REQUIREMENTS	CREDITS
Courses coming into the 4+1: (12 Credits)	
SED 425 Assesament (articulating as SED 553 UM)	3
SED 435 Program Planning (articulating as SED 543 at UM	3
SED 420 Special Education Law (articulating as SED 520 at UM)	3
SED 355 Transition Issues for Students with Disabilities (*This course will be revised and re-numbered at UMM to a 400-level course)	3

Upon completing the required shared courses (12 credits) and completing requirements outlined below, students may complete the M.Ed. at the University of Maine in one year.

+1 Courses to be taken at UMaine	
EHD 510 Introduction to Education Research	3
SED 520 Spec Ed Regs, Procedures, and Case Mgmt	3
SED 544 Math Methods in Special Education	3
SED 545 Intervention for Reading Difficulties	3

SED 532: Behavior Management and Intervention	3
SED 605: Critical Issues in Special Education	3
SED 598: Intervention of Writing Difficulties.	3
Total	33

Similarly, UMM undergraduate elementary education and secondary education majors with a concentration in Special Education will be eligible to apply for the 4+1 program after completing SED 201 Dimensions of Exceptionality and after successful completion of Praxis Core Series of Assessments. These students will complete the four advanced special education courses (400- or 500- level)within their undergraduate concentration, and articulate these courses into the +1 arrangement, allowing them to graduate in 5 years with certification in Special Education/high incidence and a M. Ed in Special Education. Given that graduate tuition is considerably more expensive than undergraduate tuition rates, the opportunity to earn twelve credits of graduate credit while paying the lower undergraduate tuition represents a significant cost savings for students.

Students who intend to apply for the 4+1 program, and students who have been accepted into the 4+1 program, must work closely with their advisors to ensure course completion aligns with the timeline outlined below.

Below is a typical progression of special education coursework for a full-time BCS student with a concentration in special education. If this student desired to apply to the 4+1 program, they could do so following First year, provided satisfactory completion of the three Praxis Core Academic Skills assessments (reading, writing, and math).

`In the post-baccalaureate Teacher Certification in Special Education program at UMM, students with a bachelor's degree in a non-education discipline complete a sequence of 30 credit hours plus 12 credit hours of student teaching, at which time they are recommended for Maine initial teacher certification (282 endorsement) by UMM's Registrar. The student does not receive a diploma or complete a degree through this program. Through the 4+1 agreement, students enrolled in UMM's Teacher Certification in Special Education program could begin coursework at UMM, then enter the +1 year at the University of Maine and graduate with a Master's in Special Education plus recommendation of UM for initial special education teacher certification in Maine (endorsement #282).

Application & Matriculation

UM students will be invited to apply into the 4+1 program at candidacy which typically occurs in their second year. Students may begin taking coursework in the

Areas of Specialization prior to candidacy and their success in those courses can strengthen their application to the 4+1 program. UMM students will apply into the 4+1 program

- after completion of 6 CH in SED coursework (specifically, SED 201 (Dimensions of Exceptionality and SED 365/4xx Universal Design and Differentiation); and
- after successful completion of Praxis Core Series of Assessments.

All students must earn B- (3.0 GPA) or better in Area of Specialization courses at UMaine, or special education concentration at UMM, to be considered for the 4+1 program. Interested students complete an application for "early admission" directly to the 4+1 program, rather than to the Graduate School. To be admitted, students must have a GPA of 3.0 or higher overall in order to double-count graduate courses towards both the undergraduate and graduate degree. Grades of B- or lower in 400- or 500-level courses will not be accepted for graduate credit. The Advising Center (UM) or Advisor (UMM) will work with the student to create a plan of study that leads to graduation within 15 months after matriculation in the Master's program. The program of study and the conditional admission is communicated to the Graduate School, and the student must make a formal application through the Graduate School during the senior year for admission to the Master's program.

Upon graduation with a bachelor's degree, and with satisfactory performance (defined as 3.0 cumulative GPA and no grade below "B-" in the courses to be double-counted for the master's degree), the student may be formally matriculated into the Master of Special Education High Incidence Disabilities program. Students who meet this requirement must matriculate within three months after receiving their bachelor's degree in order to use the joint credits.

To maximize success for UMM students in this program, we propose a special track for part-time students. UMM students are often part-time and unable to be take advantage of a 4+1 agreement. We propose that qualified part-time students be allowed to double-count the four designated classes and apply them to a Master's degree if they complete the program in 24 (rather than 15) months.

Approval

Special Education Program Chair:

School of Learning and Teaching Director:

College of Education and Human Development
Associate Dean of Accreditation and Graduate Affairs:

College of Education and Human Development Dean:

College of Education and Human Development
Graduate Certificate Proposal Routing Slip

Sat to committee 4/1/19

Date: _____ 3/14/2019 _____

From: **School of Learning and Teaching**
   Special Ed Program
   College of Education & Human Development

Item: **Graduate Certificate Proposal**
   4+1 in High Incidence Disabilities
   University of Maine & University of Maine at Machias

Please forward to the next person or department on the list below.

* *

DR-E Deborah Rooks-Ellis Program Coordinator

_ST_ Shihfen Tu, Director of School of Learning and Teaching

_SW_ Sherrie Weeks, COEHD Curriculum Committee

_JA_ Jim Artesani, Associate Dean

_TR_ Tim Reagan, Dean of COEHD

_____ Graduate Board

I.   Full Program Title
Degree: Master of Science
Area: Data Science and Engineering
CIP Code: 30.3001

Persons Responsible for Planning
Kate Beard, Graduate Coordinator, Spatial Informatics Programs
Penny Rheingans, Director, School of Computing and Information Science
348 Boardman Hall, University of Maine, Orono, ME 04469-5711

II.   Program Objectives

We propose a M.S. degree in Data Science and Engineering as a hybrid degree with both online and in-class options. The near-term goal is that the graduate program may be completed entirely on the campus in Orono, entirely online, or through a combination of courses taken online and on-campus at the Orono and other UMS campuses. Ultimately, as a general rule, students participating in courses online view class videos and accomplish assignments at any time throughout a week. They have the weekly opportunity to participate in a one to two-hour "live" discussion session with the professor at a mutually convenient time for distance class members prior to due dates for weekly assignments. Many of the graduate courses are already offered under this dual method of offering the course live for on-campus students with students at a distance viewing the class sessions at times that meet their schedules. Initially, some thematic core and domain specialization courses will be offered only on-campus with the expectation that over time, a majority of courses offered from UMaine will move to either hybrid dual or solely online versions. Regardless, it will be possible to earn the degree immediately online even though the selection of thematic core and domain specialization courses may be limited initially.

The program includes a set of core courses grouped in themes and a set of domain specialization courses. Students may focus solely on the Data Science and Engineering core or tailor the degree to emphasize one or domain specializations. To complement both thematic core and domain specializations, some courses may be taken in-class or by distance from other Maine universities if pre-approved for inclusion in graduate student Programs of Study assuming that other program requirements are met.

A. Program Rationale
Data science relies on a novel mix of mathematical and statistical modeling, computational thinking and methods, data representation and management, effective information presentation, and consideration for responsible use of data in the context of various fields of domain expertise. Data science requires a deep understanding of how data are acquired and an understanding of the semantics of the data, which strongly influences how data are processed, analyzed, stored, accessed, and presented. Data lineage, data quality, quality assurance, data integration, storage, privacy, and security are all critical topics in a robust data science program.

1

Longer-term management and reuse of data is also becoming critical, so longer-term curation and data preservation must also be addressed.

Data science and engineering has become a critical skill field for the 21st century. A host of new technologies (advanced computer modelling, smart sensor networks, high-precision lab instruments, wireless telecommunications, smart devices, and social media) are generating data collections at unprecedented rates. There are numerous new applications for such data in engineering, environmental, and social sciences as well as in business, industry, and government. The pervasive application of artificial intelligence (AI) techniques in continuous mining of big data across diverse domains is now viewed as essential by businesses and government in improving decision-making and acquiring insights that were not previously possible.

Data science and engineering addresses the challenges of capturing, curating, managing, processing, analyzing, and translating massive, complex, heterogeneous, and real-time data into manageable forms, new information, and insights. The engineering aspects involve the design and development of information systems and data infrastructure to incorporate and implement the new information and insights. For businesses, governments and academic institutions throughout Maine and beyond there is a growing need for a workforce well trained in exactly such skills.

The University of Maine has a solid foundation of existing strengths and resources for developing a Data Science and Engineering M.S. degree offering. The School of Computing and Information Science will provide the initial primary core course content. Additional domain specializations are being developed in collaboration with other units on campus. These units include the Department of Electrical and Computer Engineering, Department of Mathematics and Statistics, School of Earth and Climate Sciences, School of Biology and Ecology, School of Marine Science, Department of Civil and Environmental Engineering, Department of Mechanical Engineering, Department of Chemistry, Department of Physics and Astronomy, Department of Psychology, Department of Molecular & Biomedical Sciences, School of Economics, and the Maine Business School. All of these units have members represented in the UMaine faculty listing that appears later in this proposal.

B. General Program Goals

The objective of the Data Science and Engineering M.S. program is to meet the growing demand for graduates with core skills in managing and analyzing complex data and analytics challenges. The degree will provide a pathway for students from diverse fields to transition to multiple data science career paths by providing them with core graduate level courses across the spectrum of the data lifecycle. In support of the interdisciplinary spirit of data science and engineering, the program is designed to accommodate students from a wide range of undergraduate degrees or other graduate degree backgrounds with options for specialization in different domains.

A collection of hybrid courses with in-class and online options will support students in residence as well as meet the needs of people currently in the workforce or who are otherwise place-bound and need training or retraining in the area of Data Science and Engineering.

C. Student Outcomes and Behavioral Objectives

Students will develop knowledge and technical skills in a subset of at least four of the following five thematic areas depending on their backgrounds and interests:
- Data collection technologies

- Data management
- Data analytics
- Data visualization and human computer interaction
- Data security, preservation, and reuse

Students will have an option to complete a 30-credit project-based MS degree, a thesis-based MS degree, or a 15-credit graduate certificate. Students completing the program will be expected to: (a) have familiarity with at least one programming language, data structures and database theory; (b) understand concepts for effectively managing data in different systems, (client-server systems as well as relational and object-oriented databases); (c) have or acquire knowledge of statistical and analytical tools (data mining, machine learning); (d) understand effective visualization techniques and the presentation of information to different audiences, and (e) be familiar with data security, curation, and preservation strategies.

III.   Evidence of Program Need

A. Workforce Needs

The importance of data science and engineering to all fields is predicted to grow exponentially and has prompted the launch of cross-agency federal research programs in data science. Six federal departments and funding agencies (NSF, NIH, DoD, DARPA, DoE, and
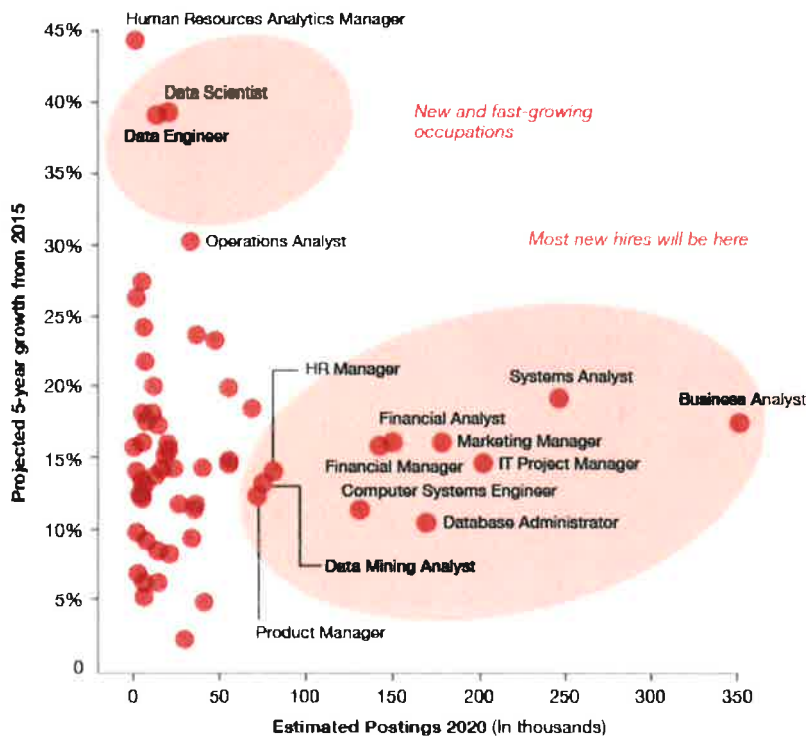
Note: Each dot represents an occupation in the US jobs market where data science and analytics skills are required.
Source: PwC analysis based on Burning Glass Technologies data, January 2017

USGS) have prioritized an initiative to accelerate the pace of knowledge discovery in large datasets [1]. In the business world [2], forecasts put the yearly demand for roles relating to data development, data science, and data engineering to reach almost 700,000 openings by 2020. It has also been reported that the United States faces a shortage of more than 140,000 trained personnel to manage and analyze big data [3]. The Business-Higher Education Forum (BHEF) in 2019 projected continuing demand for graduates with data science and analytical skills [4]. The workforce need is so great and UMaine expertise is so well established that *Data Science and Engineering* has been officially recognized by the University of Maine as an *Emerging Area of Excellence* worthy of special attention in providing support [5].

[1] Big Data Research and Development Initiative, Obama administration 2012
[2] http://www.forbes.com/sites/siliconangle/2012/02/17/big-data-is-big-market-big-business/
[3] Manyika,J., Chui, M., Brown, B., Bughin,J., Dobbs,R., Roxburgh, C., Hung Byers, A. 2011 Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute
[4] https://www.amstat.org/asa/News/New-Report-Highlights-Growing-Demand-for-Data-Science-Analytics-Talent.aspx
[5] UMaine Signature and Emerging Areas of Excellence, https://umaine.edu/areas/data-science-and-engineering/

B. Targeted Audiences Related to the Need for Graduate Education in this Field

The advanced knowledge provided by graduate-level data science programs is needed across a wide range of commercial, non-profit, and government settings. Individuals in all areas of private and public enterprise need data science skills for data management, analytics, planning, and decision support. Maine's industry and businesses, such as Kepware Technologies, IDEXX Laboratories, Jackson Laboratory, Bath Iron Works, Maine Health Data Organization, Maine's HealthInfoNet, RM Beaumont Corp, Applied Thermal Sciences, and GWI, and startup companies such as CashStar and GreenPages Technology Solution, among many others stand to profit from data science and engineering research. In particular, we address the need for trained data analysts, which Maine's Department of Labor predicts to grow the fastest among all computer-related jobs in Maine.

C. Similar Programs Offered by Other Universities

Over 30 universities offer an online M.S. degree or certificate in Data Science. Some of these programs offer specializations, such as analytics, artificial intelligence, or data engineering. Part-time and full-time enrollment options are available for on-line data science degrees. Within the New England region, the following data science programs are offered:

Massachusetts: MIT: MicroMasters® program in Statistics and Data Science, Harvard: Graduate Certificate in Data Science. Northeastern, Boston University, UMass Amherst, and UMass Boston all offer graduate certificates in Data Analytics and/or Business Analytics. Bay Path University: Master of Science in Applied Data Science.

Connecticut: Central Connecticut State University: Graduate Certificate in Data Mining, Master of Science in Data Mining; Wesleyan University: Certificate in Applied Data Science

New Hampshire: New England College: Master of Science in Data Analytics and Business Statistics. Southern New Hampshire University: Master of Science in Data

Analytics; University of New Hampshire: Graduate Certificate in Data Science, Graduate Certificate in Analytics, Master of Science in Analytics.

Vermont: University of Vermont: Master of Science in Biostatistical Sciences, Masters in Complex Systems and Data Science

Rhode Island: Brown University: Master of Science in Data Science – Campus only

University of Maine System: The School of Computing and Information Science will provide the home for this degree program. Individuals involved on the **University of Maine** campus are listed under the Personnel Section below.

The **University of Southern Maine (USM)** is also developing a Data Science graduate program proposal. We believe the programs will be different and highly complementary, with students benefiting from the opportunity to choose between them. The programs will be different in flexibility, delivery method, and expected preparation of students. Based on the USM Intent to Plan (ITP), the USM program would consist seven specific core courses with elective available in a number of tracks, with all courses delivered only face-to-face. Students would be required to have a specific background in programing, calculus, probability, and statistics, with required remedial work for those without that background. The proposed UMaine program offers a broader range of paths into and through the MS degree and thus allows students with greater variations in undergraduate backgrounds to pursue the UMaine graduate program. Initially, the courses included in the UMaine Data Science program will be a mix of those available either face-to-face or online; in time, all will have online options. We believe the two programs can share some course offerings as a way to obtain the most benefit from resources, while providing the most flexibility for students. We have made initial contact with those responsible for the USM proposal and will be seeking to work with them to find ways the two programs can best support each other.

Dr. Matthew Dube, lead proposer for an undergraduate Data Science degree at **University of Maine at Augusta** (UMA) has been contacted about sharing upper level courses and providing a pathway for students completing the undergraduate degree from UMA to continue in Data Science, through development of a joint Double Up (4+1) offering. That is, by double counting up to three courses, a UMA graduate may complete the MS Data Science in a single year.

All USM campuses that offer academic courses at the 400 level or above that are suitable for inclusion in a MS Data Science and Engineering graduate program were contacted. We were particularly interested in engaging instructors on these campuses that are able and willing to teach such courses through distance technologies. We are providing flexible options for students to include selected courses from other Maine universities (pre-approved, 400 level and above taken in-class or by distance) in their graduate student Programs of Study. See Section IV for details on Maine campuses to be involved. More may be added over time. We will create an interdisciplinary and multi-campus *Data Science and Engineering Oversight Committee* to provide guidance for program oversight over time. The chair of the Oversight Committee will be typically one of the SCIS Graduate Coordinators or will otherwise be appointed by the Director of SCIS.

D. Enrollment Projections for Five Years

The target enrollment goals over the first five years are as follows:

2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
3	10	17	25	30

Because the program is designed to attract students from a broad range of undergraduate degrees and the program will be offered both on-campus and by distance, we believe the target enrollment numbers listed are conservative. These are numbers we can readily handle with existing course offerings and faculty advisors. Indeed, the demand may be higher. Notice that because the program will be available immediately, it will be too late to list the program in the official graduate catalog in the first year and there will be little time to market and accept applications. As such, we expect only a small number of students to enroll in January 2020 of the first year.

IV.   Program Content

A. General Program Description

The Data Science and Engineering program blends mathematical and statistical modeling, with computational methods, data representation and management, effective presentation for human consumption. General skills for managing and analyzing data can benefit from domain knowledge or interaction with domain experts. This program thus provides options and pathways to specialize general data science and engineering skills development with domain specialization.

The University of Maine Data Science and Engineering graduate programs and courses provide students with foundational knowledge and an overview of data science. They also provide students with the ability to specialize or gain breadth across a broad range of data science and engineering topics. While foundation and overview required courses are interdisciplinary and some will be taught by teams from multiple disciplines, specialty courses included within the graduate programs are typically drawn from multiple and numerous disciplines

Program Options: The University of Maine proposes to offer the following graduate programs in Data Science and Engineering:

> ***MS Data Science and Engineering (MS DSE)*** with a ***Thesis Option*** (24 credits of coursework and 6 thesis credits) and an all coursework ***Project Option*** (30 credits of coursework requiring 3 of the credits to be a project or internship course),
>
> ***Graduate Certificate in Data Science and Engineering*** (15 credits of coursework), and
>
> ***Double Up [4+1] Option.*** For this option, any qualifying undergraduate student in any degree program at the University of Maine may begin this option in their junior year enabling them to complete their bachelor's degree and the MS DSE in five years. This option will be open to other UMS campuses on a case-by-case basis.

Admission Requirements: Students with undergraduate degrees in any field may apply. Candidates with two semesters of calculus (e.g., MAT 126, 127), a semester of statistics (e.g., MAT 434), and proficiency in programming have more options for classes they may pursue. Thus, students without these background pre-requisites will be encouraged take foundation courses in which their background is lacking. The foundation courses will count towards the

degree and will better prepare students for several of the more advanced courses. However, all students need to pay close attention to prerequisite courses in the core theme and domain specialization areas and either meet the prerequisites or choose alternative courses.

Program Requirements:

(1) MS Data Science and Engineering (MS DSE) with **Thesis Option.** The candidate must complete 30 credits consisting of:

    (a) Required Courses: DSE xxx Practicum in Data Science (3cr), SIE 501 Introduction to Graduate Research (1cr), SIE 502 Research Methods (1cr), and INT 601 Responsible Conduct of Research (1cr)

    (b) 12 course credits from at least four of the five Core Theme Areas

    (c) 6 further course credits from within the Foundation Courses, Theme Areas, or Domain Specializations

    (d) 6 credits of thesis

(2) MS Data Science and Engineering (MS DSE) with **Project Option.** The candidate must complete 30 credits consisting of:

    (a) Required Courses: DSE xxx Practicum in Data Science (3cr)

    (b) 12 course credits from at least four of the five Core Theme Areas

    (c) 12 further course credits from within the Foundation Courses, Theme Areas, or Domain Specializations

    (d) 3 credits of graduate project (example: SIE 589 Graduate Project) or graduate internship (example: SIE 590 Information Systems Internship)

(3) Graduate Certificate in Data Science and Engineering (GC DSE). The candidate must complete 15 credits consisting of:

    (a) Required Courses: DSE xxx Practicum in Data Science (3cr)

    (b) 9 course credits from at least three of the five Core Theme Areas

    (c) 3 further course credits from within the Foundation Courses, Theme Areas, or Domain Specializations

(4) Double Up [4+1] Option (https://umaine.edu/graduate/programs/doubleup/). The candidate must apply for admission to the Double Up [4+1] Program before or during their undergraduate junior year. An applicant should expect to have an overall minimum undergraduate grade point average of 3.25, must have completed at least a semester course in calculus, and must have three letters of recommendation from current or previous university instructors. In the senior year, provisionally admitted students must submit the formal application to the Graduate School. Provisionally admitted Double Up students with an undergraduate grade point average of 3.25 or better may take up to 9 credits of graduate-level courses in Data Science and Engineering toward the **MS DSE (Project Option).** These graduate courses may also count towards the Bachelor's degree (joint credits) but they must also be part of the student's Master's Program of Study in Data Science and Engineering. Upon graduation with a bachelor's degree, and with satisfactory performance in courses taken as an undergraduate, the student may be formally matriculated into the master's program. Students who meet these requirements must matriculate in their master's program within one semester/term after receiving their bachelor's degree in order to use the joint credits.

B. Outline of Courses

Please note that in the listings of courses that follow, several courses have been included from other Maine campuses that may be highly appropriate for some students to take and include on their graduate programs of study. The listings of external courses from other UMS campuses in the tables below are not exhaustive and are likely to grow over time. Although the Graduate School policy is to allow up to two appropriate courses (six credits) to be transferred from other universities as a matter of course, we are proposing in this instance that up to three vetted external courses be allowed to be included on student graduate programs of study as a matter of course and perhaps more might be accepted through a special exception process.

Instructors teaching the listed courses on other UMS campuses have been contacted to determine whether they will allow qualified students affiliated with the proposed programs to take their courses and whether they may want to potentially serve on graduate committees, and otherwise be involved with the program. While not all have responded to date, none of the instructors listed have conveyed objections to having their courses listed.

While explicit prerequisite courses are listed in the course tables that follow, equivalent courses or backgrounds are typically accepted by instructors. Different applicants will have different academic backgrounds enabling them in consultation with their advisors to select among course paths that meet their background and interests. Course instructors and advisors will work with students to ensure that adequate backgrounds exist so that students are likely to succeed in their mutually chosen course path through the curriculum.

Foundation Courses. Admitted candidates missing appropriate background pre-requisite courses are encouraged to take these foundation courses as appropriate and as advised by their graduate committee and/or advisor. The foundation courses may count towards the degree if approved on the student's Graduate Program of Study. The two Foundation Courses include:

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
DSE5xx	Introduction to Statistical Methods in Data Science or	3	One semester calculus	Yes, in 2020	Orono
STS434	Introduction to Statistics or	3	MAT 228	No	Orono
ECE515	Stochastic Processes	3	ECE 316	No	Orono
SIE 507	Information Systems Programming	3	Program admission or instr. permission	Yes	Orono

Required Course in All DSE Graduate Programs. Whether in a graduate degree or graduate certificate program, all students must complete the following introductory course. This is a new interdisciplinary team-taught course that will be structured around an overview of data science and engineering topics and tools as applied to large case study data sets.

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
DSE5xx	Practicum in Data Science	3	Program admission or instr. permission	Yes, in 2020	Orono

Data Science and Engineering Core Themes. The core themes are:
        Theme 1: Data Collection Technologies
        Theme 2: Data Management
        Theme 3: Data Analytics
        Theme 4: Data Visualization and Human Interaction
        Theme 5: Data Security, Preservation, and Reuse
Additions and deletions to the courses listed under each of the themes are likely to occur over time as the field changes and as a result of assessments over time. A single course may not count under more than one theme or domain specialization category. Courses currently contained within the core themes include the following:

Theme 1: Data Collection Technologies

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
SIE559	Geosensor Networks	3	Program admission or instr. permission	Yes	Orono
ECE484	Communications Engineering	3	ECE 314 and ECE 316	Yes	Orono
ECE585	Foundations of Wireless Communications	3	ECE 484	Yes	Orono
SFR5xx	Advanced Remote Sensing Analysis and Applications	3	Instr. permission	No	Orono
SFR609	Remote Sensing Problems	3	Instr. permission	No	Orono
SVT 437	Practical GPS		SVT 341	Yes	Orono
SVT531	Advanced Digital Photogrammetry	3	None listed	Yes	Orono
SVT532	Survey Strategies in Use of Lidar	3	None listed	Yes	Orono
SMS540	Satellite Oceanography	3	SMS 501 and SMS 541 or permission	No	Orono

Theme 2: Data Management

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
SIE550	Design of Information Systems,	3	Program admission or instr. permission	Yes	Orono
SIE557	Database Systems Applications,	3	Program admission or instr. permission	Yes	Orono
COS580	Topics in Database Management Systems	3	Instr. permission	No	Orono
COS5xx	Cloud Computing	3	tba	No	Orono
SIE580	Formal Ontologies: Principles and Practice	3	Program admission or instr. permission	Yes, 2019	Orono
BUA561	Knowledge Management and Decision Support	3	Senior or grad student	Yes	Orono

Theme 3: Data Analytics

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
STS531	Mathematical Statistics	3	C or better in	No	Orono

			MAT 425, STS 434 or permission		
STS533	Stochastic Systems	3	C or better in STS 434	No	Orono
PSE509	Experimental Design	4	None listed	No	Orono
SIE503	Principles of Experimental Design	1	SIE 501	Yes	Orono
COS570	Introduction to Artificial Intelligence	3	Instr. permission	No	Orono
BIO593	Advanced Biometry	3	Course in statistics	No	
COS5xx	Computer Vision	3	tba	No	
SIE5xx	Natural Language Processing	3	tba	Yes, 2020	Orono
ECO530	Econometrics	3	MAT 126 & MAT 215/MAT 232, or permission	No	Orono
ECO531	Advanced Econometrics & Applications	3	B or better in ECO 530 or permission	No	Orono
ECO532	Advanced Time Series Econometrics	3	ECO 530 or permission	No	Orono
BUA601	Data Analysis for Business	3	Intro stats and/or calculus	Yes	Orono
EHD572	Advanced Qualitative Research	3	EHD 571 or equivalent	No	Orono
EHD573	Statistical Methods in Education I	3	None listed	Yes	Orono
EHD574	Statistical Methods in Education II	3	EHD 573 or equivalent	Yes	Orono
ECE590	Neural Networks	3	Permission	No	Orono
SFR528	Qualitative Data Analysis in Natural Resources	3	EHD 571 or permission	No	Orono
SMS595	Data Analysis Methods in Marine Sciences	3	MAT 126 or equivalent	No	Orono
CMJ601	Seminar in Research Methods	3	permission	No	Orono
PSY540	Advanced Psychological Statistical Methods and Analysis I	3	PSY 241 or equivalent	No	Orono
PSY541	Advanced Psychological Statistical Methods and Analysis II	3	PSY 241 or equivalent	No	Orono

Theme 4: Data Visualization and Human Interaction

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
SIE515	Human Computer Interaction	3	Program admission or instr. permission	Yes	Orono
SIE5xx	Spatial Interaction Design	3	tba	Yes	Orono
SIE516	Virtual Reality: Research and Applications	3	Program admission or instr. permission	No	Orono
COS5xx	Data Visualization	3	tba	No	Orono

Theme 5: Data Security, Preservation, and Reuse

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
COS5xx	Engineering Privacy in Software Systems	3	tba	Yes, 2020	Orono
SIE525	Information Systems Law	3	Program admission or instr. permission	Yes	Orono
DIG500	Introduction to Digital Curation	3	None listed	Yes	Orono
DIG510	Metadata Systems	3	DIG 500 recmmdd	Yes	Orono
DIG550	Digital Preservation	3	DIG 500, 510, & 540 recmmdd	Yes	Orono
CYB 501	Cybersecurity Fundamentals	3	Graduate Standing	Yes	Augusta*
CYB 520	Cybersecurity Policy and Risk Management	3	Graduate Standing	Yes	Augusta*
CYB 551	Cybersecurity Investigations	3	Graduate Standing	Yes	Augusta*

* - Only 3 external courses in total (9 credits) may be included on a student's Graduate Program of Study.

Data Science and Engineering Domain Specializations. The current domain specializations include:

Domain A: Spatial Informatics
Domain B: Bio-Informatics/Biomedicine
Domain C: Business Information
Domain D: Data Science for Social Good

Additions and deletions to the courses listed under each of the domain specializations are likely to occur over time as the field changes and as a result of course assessments over time. A single course may not count under more than one theme or domain specialization category. Courses currently contained within the domain specializations include the following:

Domain A: Spatial Informatics

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
SIE505	Formal Foundations for Information Science	3	Program admission or instr. permission	Yes	Orono
SIE509	Principles of Geographic Information System	3	Program admission or instr. permission	Yes	Orono
SIE510	GIS Applications	3	Program admission or instr. permission	Yes	Orono
SIE512	Spatial Analysis	3	Program admission or instr. permission	Yes	Orono
SIE555	Spatial Database Systems	3	Program admission or instr. permission	Yes	Orono
SIE558	Real-time Sensor Data Streams	3	Program admission or instr. permission	Yes	Orono
INT527	Integration of GIS and Remote Sensing Data Analysis in Natural Resource Applications	3	Permission & grad standing	No	Orono
SFR 500	Applied GIS	3	Instr. Permission	No	Orono

SMS595	Data Analysis Methods in Marine Sciences	3	MAT 126 or equivalent	No	Orono
CIS 461	Spatial-Temporal Information Science	3	CIS 360 or permission	Yes	Augusta*
GEO605	Remote Sensing	3		No	USM*
GIS 428	Web-Based Maps, Applications & Services	3	GIS 230 and GIS 330, or permission	Yes	Machias *
GIS 500	GIS I	3	Permission	Yes	Machias *
GIS 5xx	Municipal Applications of GIS	3	GIS 500 or permission	Yes	Machias *
GIS 600	GIS II	3	Permission	Yes	Machias *
GIS 6xx	Community Applications of GIS	3	GIS 500 or permission	Yes	Machias *
GIS 6xx	Remote Sensing & Image Analysis	3	GIS 500 and GIS 600, or permission	Yes	Machias *

* - Only 3 external courses in total (9 credits) may be included on a student's Graduate Program of Study.

Domain B: Bio-Informatics/Biomedicine

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
BMB502	Introduction to Bioinformatics	3	BMB 280 or permission	No	Orono
BMS625	Foundations of Biomedical Science and Engineering	1 - 4	None	No	Orono
ECE583	Coding and Information Theory	3	ECE 515 or permission	No	Orono
SIE505	Formal Foundations for Information Science	3	Program admission or instr. permission	Yes	Orono

Domain C: Business Information

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
BUA605	Creating and Capturing Value in the Digital Economy	3	BUA 270 or equiv or permission	Yes	Orono
BUA626	Management of Contemporary Organizations	3	BUA 325 or equiv or permission	Yes	Orono
BUA668	Electronic Commerce	3	BUA 605 or permission	Yes	Orono
MBA504	Probability and Statistics for Business Decision Making	3		?	MBS
MBA623	Financial Engineering	3	MBA 505	?	MBS
MBA629	Financial Modeling	3		?	MBS
MBA649	Introduction to System Dynamics	3		?	MBS
MBA665	Consumer Behavior	3		?	MBS
MBA670	Management Science	3		?	MBS
MBA674	Strategic Management of	3	BUS 340 or EDU	No	MBS

	Technology and Innovation		671 & grad stndng		
MBA675	Production/Operations Management	3		?	MBS
MBA676	Data Management and Analytics	3	MBA Program or permission	Yes	MBS
MBA677	Information Visualization	3	MBA 676	Yes	MBS
MBA678	Data Mining	3	MBA 676	Yes	MBS
CIS450 / BUA450	Data Mining	3	CIS 255 or CIS 352 or CIS 360 or CIS 449 or permission	Yes	Augusta*

* - Only 3 external courses in total (9 credits) may be included on a student's Graduate Program of Study

Domain D: Data Science for Social Good

Course Number	Course Title	Crdts	Prerequisites	By Distance	Campus
HTY 665	Digital and Spatial History	3	Grad standing	Yes	Orono
CMJ 593	Special Topics in Communication: Social Media and Digital Cultures	3	Instr. permission	No	Orono

C. Development of New Courses

Courses indicated with xx in the numbering column of the courses are not yet fully approved. Most are well along in the planning stages and are part of the regular process of reevaluating, revising, and renaming courses as the participating graduate programs evolve over time. All of such courses are part of the teaching loads of existing or newly incoming professors. Upon approval of the proposal, any and all such indicated courses will be moved through campus approval processes if they have not already begun that process.

D. Research in Program Design

Data science and the engineering of new methods and systems for analyzing and processing the immense data streams of our time are high priorities for federal agencies as indicated in Section III.A. We are currently hiring a computer science faculty member with data science teaching and research core interests. The chosen candidate will begin in September 2019 to help with the initiation of this graduate program and related research. The *MS Data Science and Engineering (Thesis Option)* program is the means by which graduate students with research interests in the domain will pursue those interests. Their graduate committees will be formed primarily from the faculty members teaching the graduate courses as set forth in this proposal. As collaborations grow among faculty supporting course work and graduate committee advising on data science and engineering topics, we expect a string of collaborative and interdisciplinary proposals for external funding to arise on these topics. We anticipate an exciting, productive, and challenging research agenda and projects to emerge. The interdisciplinary nature of the evolving field and the new bridges that are certain to be built among faculty, researchers, students, and industry across Maine make this an important effort in advancing knowledge for all of us.

E. Independent Study and Field Practicums

Standing graduate courses for independent study, independent projects, field experience, and graduate internships already exist. One or more of such courses are affiliated with most of the academic programs affiliated with this proposal whether they are on the Orono campus or

elsewhere. In some instances, professors may desire to continue using the course designator and syllabus requirements used already with the independent study or internship courses affiliated with their home faculty units. Although not critical at this juncture, reasons for moving to DSE course designators and more standardized syllabi for such courses may arise over time. If so, *DSE 6xx Data Science and Engineering Project* and *DSE 6xx Data Science and Engineering Internship* may be readily proposed and implemented on the UMaine campus.

F. Impact on Existing Campus Programs
Most graduate faculty members are very interested in working with and teaching graduate students. That is why we are graduate faculty members and why we are here. This is our chosen life. Most of us see nothing but positive benefits accruing from expansion of graduate programs and the advising of increased numbers of students on projects that are of interest to us, our students, science, industry, and society in general. If classes and advising responsibilities start to become too pressing, we have the option of becoming more selective in the quality and numbers of students we admit. Based on the target student populations submitted in this proposal, we feel the load may be handled by the current involved faculty which is dispersed across numerous academic domains and the program will highly complement our existing and ongoing graduate programs.

V. Program Resources

A. *Personnel*
Faculty expertise in data science and engineering is distributed across colleges and units. Expertise includes large-scale complex data management, data semantics, high-performance computing, wireless communications theory, sensor technology, human-computer interactions, cybersecurity, statistical analysis of spatial and temporal data, along with policy research in data and information science. University of Maine Faculty participating in course teaching or willing to serve on graduate advisory committees are listed below.

A search is currently underway for a new Computer Science professor with a research and scholarly specialization in Data Science. This person is expected to be on campus in Fall 2019 and will be developing new courses to be included in this new degree program. In time, they could be expected to take a leadership role in this program.

Faculty	Specialization	Department
Ali Abedi	Wireless Sensor Networks	Electrical and Computer Engineering
Sofian Audrey	Artificial Intelligence, Machine Learning	School of Computing and Information Science
Kate Beard	Geographic Information Science, Spatial Statistics	School of Computing and Information Science
Kathleen Bell	Econometrics	School of Economics
Sudarshan Chawathe	Databases, Data Mining, Algorithms	School of Computing and Information Science
Phil Dickens	Cloud Computing, High Performance Computing	School of Computing and Information Science
Max Egenhofer	Database Systems, Spatial-temporal Reasoning	School of Computing and Information Science

Sepideh Ghanavati	Data Privacy and Security	School of Computing and Information Science
Nicholas Giudice	Human Computer Interaction	School of Computing and Information Science
Pushpa Gupta	Statistics	Department of Mathematics and Statistics
Ramesh C. Gupta	Statistics	Department of Mathematics and Statistics
Torsten Hahmann	Data Semantics, Ontologies, Artificial Intelligence	School of Computing and Information Science
Daniel Hayes	Remote Sensing, Image Processing	School of Forest Resources
Raymond Hintz	Surveying, Photogrammetry	School of Engineering Technology
Shaleen Jain	Engineering Data Analytics	Civil and Environmental Engineering
Jaehong Jeong	Spatial Statistics	Department of Mathematics and Statistics
Nory Jones	Management Information Systems	Maine Business School
Jon Ippolito	New Media	School of Computing and Information Science
Andre Khalil	Computational Biomedicine, Radiomics	Chemical and Biomedical Engineering
Ben King	Bioinformatics	Molecular and Biomedical Science
Anne Knowles	Historical GIS, Geovisualization, and Digital Humanities	History
Craig Mason	Biobehavioral Informatics and Quantitative Methods	Education and Applied Quantitative Methods
Brian McGill	Ecoinformatics	School of Biology and Ecology
Cyndy Loftin	Wildlife Modeling, Geographic Information Systems	Dept. of Wildlife, Fisheries, and Conservation Biology
Silvia Nittel	Spatial Databases, Geosensor Networks	School of Computing and Information Science
Harlan Onsrud	Data and Information Policy	School of Computing and Information Science
Nigel Pitt	Mathematics	Chair, Mathematics and Statistics
Parinaz Rahimzadeh-Bajgiran	Remote Sensing, GIS	School of Forest Resources
Nimesha Ranasinghe	Multisensory Interfaces, Embedded Systems, Sensors and Actuators	School of Computing and Information Science
Penny Rheingans	Data Visualization	School of Computing and Information Science
Judith Rosenbaum	Media and Society	Communication and Journalism
Andrew Thomas	Oceanography, Ocean Satellite Data	School of Marine Sciences
Roy Turner	Artificial Intelligence	School of Computing and Information Science
Mike Scott	New Media	School of Computing and Information Science
Michael Weber	Marketing	Maine Business School

Zheng (David) Wei	Statistics	Department of Mathematics and Statistics
Aaron Weiskettel	Forest modeling	School of Forest Resources
Manuel Woersdoerfer	Computer/Engineering Ethics, Business Ethics	School of Computing and Information Science
Terry Yoo	Computer Graphics, Image Analysis	School of Computing and Information Science

Professors from additional UMS campuses invited to potentially serve on graduate committees and/or teaching courses which have been vetted and will be accepted for transfer credits are included in the following table.

Faculty	Specialization	Department
Matthew Dube	Spatial-Temporal Reasoning, Data Visualization, Data Mining, Social Science Applications	Computer Information Systems, University of Maine at Augusta
Henry Felch	Cybersecurity and Computer Information Systems	Cybersecurity and CIS, University of Maine at Augusta
Betina Tagle	Cybersecurity and Computer Information Systems	Cybersecurity and CIS, University of Maine at Augusta
James Suleiman	Management Information Systems, Computer Supported Cooperative Work, Text Analytics	USM School of Business
Tora Johnson	Regional Planning Applications of GIS, Natural Resource Decision Support, Participatory GIS	GIS Laboratory, University of Maine at Machias

B. Facilities

Information Infrastructure: Several infrastructure resources already exist to support a strong Data Science and Engineering initiative. The University of Maine has established infrastructure in high-performance networks and computer clusters to support big data research. The Three Ring Binder and the Maine Research and Education network tie together large portions of Maine's network traffic including network traffic for all K-12 schools and nearly all libraries in the state. This network provides a backbone for efficient data distribution and collection.

Research Labs and Centers: Existing research centers and laboratories provide a wealth of resources which may be leveraged to support this degree program. These include:

Advanced Computing Group (ACG): The ACG provides computing infrastructure and support. It offers high performance computing resources, cloud computing services, data storage solutions and data management plan assistance. The ACG currently has a supercomputing cluster with 512 processor cores, over 300 TB data storage capacity, a large shared-memory computation server, GPU-accelerators, and a high-performance visualization server.

CompuMAINE Lab: The Computational Modeling, Analysis of Images, and Numerical Experiments Lab is a computational lab dedicated to digital science and data driven outcomes. By developing and implementing novel signal processing & image analysis techniques, and computational modeling, CompuMAINE integrates mathematics, physics, artificial intelligence, machine learning, data mining, and computational engineering approaches to study a wide variety of applications. Focused research projects are centered on radiomics, a

new field of medical study that aims to extract large amounts of quantitative features from medical images using data-characterization algorithms. Applications include Medicine (cancer, neuroscience, muscular dystrophy), Biophysics (neuro-development, cell nucleus architecture), Biomedical Engineering (artificial bone implants, protein modeling, astrobiology), Physics / Geophysics / Astrophysics (climate change, surface science, solar physics, interstellar medium, cosmology), and Pure Mathematics (fractal structures in Pascal's Triangle).

Geosensor Lab: The Geosensor Lab investigates distributed wireless sensing applications and the role of data stream engines in fast processing of large real time spatio-temporal data streams, and executing stream window queries over them efficiently.

MaineSAIL: The Maine Software Agents and Artificial Intelligence Laboratory takes an agent-based approach to AI, dealing with hardware/software systems that perceive their environment, make decisions about how to behave, and take action. Many of MaineSAIL's projects have as their domain in the intelligent control of autonomous vehicles, for instance autonomous underwater vehicles (AUVs), or multi-AUV systems, such as autonomous oceanographic sampling networks (AOSNs).

National Center for Geographic Information and Analysis: NCGIA-Maine conducts research on all aspects of geographic information science. Research aims to advance spatial information theories and develop new spatial information technologies that help humans in their everyday lives, in their interaction with the environment, with each other, and with computers, and to generally advance our understanding of spatial and temporal phenomena in our geographic surroundings.

Spatial Knowledge and Artificial Intelligence Lab (SKAI): The SKAI lab investigates methods for computationally capturing, interpreting, and processing the semantics of data from structured and unstructured sources, turning data into knowledge that informs human analysis and powers intelligent systems.

Virtual Environments and Multimodal Interaction Lab (VEMI): VEMI is a fully integrated research facility combining immersive virtual and augmented reality technology. This research lab supports an integrative approach called neurocognitive engineering, which uses psychophysical techniques to connect theories from human information processing and multimodal spatial cognition to develop and test new technologies. Studies are based on behavioral experiments with human participants in both real environments and virtual reality (VR).

Wireless Communication Labs: Wireless sensing leverages resources spread across several departments and research centers. The Maine Center for Next Generation Wireless Communications, consists of four laboratories: the Antenna Characterization Laboratory, the High Power RF and Microwave Circuits Laboratory, the Wireless Communications and Networking Laboratory and the Environmental Testing Laboratory. These four laboratories, in conjunction with the Wireless Sensing Lab (Wise-Net), form the base for wireless communications and networking research at the Electrical and Computer Engineering Department. WiSe-Net Lab hosts the NASA's only large scale (42 ft diameter) inflatable lunar habitat model in the world that is instrumented with passive wireless sensors.

Classrooms: The School of Computing and Information Science uses one small classroom with a traditional class seating arrangement (Room 136 Boardman, 25 seats) and two conference table style classrooms (Room 326, 15 seats and Room 336, 20 seats) to offer courses both on-campus as well as record the sessions for later viewing by distance students. While the rooms are capable of live synchronous distance delivery and conferencing, we have learned from

experience that students at a distance very much prefer to view lecture and in-class discussion sessions on their own schedules. These rooms may also be used by professors for "live" once-a-week discussion sessions with distance students although professors may also accomplish those sessions from their offices or home depending on the facilities needed. Other campus academic units typically have similar classroom capabilities available for small classes. For larger classes, distance classrooms may be scheduled centrally through the campus.

C. *New Equipment, Facilities, and Space*

Based on the conservative number of students to be accepted into the program and due to extensive labs and physical facilities already supporting current graduate programs, no new equipment is required for support of this explicit program in the near future.

As a general need across all of the SCIS graduate distance course offerings, the two conference rooms mentioned in the previous section need upgrading with two new computers each (one with a touch screen), two cameras each, and ceiling microphones. This is a general upgrade challenge to enhance the distance experience for all graduate distance courses in SCIS. Courses in the *MS Data Science and Engineering* curriculum that are offered by other units on the Orono campus or on other campuses have these same or similar challenges. The provisioning of recording and distance capabilities are typically dealt with on an academic unit by unit basis or the units use campus-wide scheduling of distance classroom facilities. Regardless, the courses listed in this proposal are operational unless otherwise specifically indicated.

While space is at a premium, an office exists for the one new faculty member already slated to be added into the SCIS program to help support both our undergraduate and graduate programs. There is high competition for research lab and graduate student space in the School of Computing and Information Science but we expect some cooperative accommodation to be worked out over time with other research faculty members and the administration as needed. Because at least half or more of the MS Data Science students are expected to participate by distance methods, this helps lessen the building office space challenges.

For those research-focused graduate students located on campus, SCIS provides working space in the first floor open labs in Boardman Hall, a student lounge, and shared office space for those graduate who serve as teaching assistants or research assistants.

D. *Library Resources*

All enrolled students, whether on-campus or participating at a distance, have access to extensive electronic journals, databases and other resources made available through Fogler Library. Library resources are currently satisfactory for supporting courses and research in Data Science and Engineering, so no additional library resources are currently anticipated. If found insufficient over time, Fogler Library has an ongoing and regular process for requesting new electronic resources and our experience is that library staff are very responsive to research needs. All enrolled tuition-paying distance students have electronic access to the usual UMaine library resources from their homes and offices.

E. *Extent of Cooperation with Other Academic Programs*

Up to a maximum of 9 credits of external graduate courses may be accepted on any graduate student's program of study if approved on the student's official graduate program of study. Courses from other USM campuses that would appear to be appropriate to accept within these parameters are listed in Section IV.B. Currently this includes courses only from USM,

UMaine-Augusta, and UMaine-Machias but this may expand over time. Accepting such courses provides great flexibility in that a student living in a community with another USM campus close by that offers an appropriate course may be able to attend that course physically. Further, if comparable or substitute data science courses are offered by distance on another campus during a semester when not offered by distance on the Orono campus, this provides extra flexibility for students pursuing their graduate degrees. External courses listed in Section IV.B. are yet tentative and we envision further acceptable additions and substitutions over time.

VI.   Total Financial Consideration

A. Anticipated Costs in First Five Years

Support Staff Member: Administrative support staff within the School of Computing and Information Science is currently managing more than a full load. Additional administrative support is critical to help with the management and marketing of this new M.S. degree program. Lack of a designated staff member to accomplish a range of specialized management, marketing, web development, web support, and outreach tasks is limiting growth of all of the SCIS graduate programs as well as affecting the undergraduate programs. Thus, this is a need that falls across several academic programs. Initially, this new program will require a half-time Program Coordinator with a total cost of approximately **$45,000 per year**.

Upgrading of Two Distance Classroom Facilities: Upgrading of the two distance conference style classrooms specified in Section V. C., which is only partly attributable to the offering of this new program, would cost approximately **$20,000**. While the current classrooms are operational, the learning experiences for distance graduate students would be substantially enhanced through such upgrades.

Social Media Marketing: Some graduate programs have well defined audiences that may be reached directly (e.g. K-12 teachers in Maine that may need well defined graduate courses or a degree to qualify for certain jobs or advancement). Other graduate degrees require explicit undergraduate degrees to pursue graduate work in that specialized field (e.g. Chemical Engineering) and again the audience is relatively narrowly defined and therefore easier to identify and contact. However, a graduate degree like Data Science is designed to draw people from many undergraduate degree backgrounds. Most successful graduate distance programs across the nation with broad audiences find social media to be one of the most effective means for identifying candidates for their programs. In order to be effective, this means of advertising is expensive.

Programs drawing from broad audiences typically need very focused social media advertising on their specific program to be successful. That is, people from Maine or elsewhere doing web searches for "online masters in data science" is a key audience to contact which should be pursued through repetitive remarketing using Google, Facebook and similar forums. Such ads also increase the visibility of the on-campus program. General promotion of all University of Maine distance offerings is beneficial but won't typically result in the leads needed to aggressively grow individual graduate programs. Thus, a minimum budget of **$8,000 per year** is needed for social media ads for the MS Data Science and Engineering program. The University of Maine has one of the lowest e-rates for tuition among land-grant, sea-grant universities and this should be heavily marketed. The social media marketing budget needed may be administered by the Division of Lifelong Learning (DLL) or by SCIS.

Other Costs: Most other costs in the first five years are likely to be incurred as part of the regular overhead costs of administering several graduate programs in SCIS. Neither Research Assistantship nor Teaching Assistantship funding is being requested to help support graduate students in this program. We expect that students participating at a distance will be self-funded or funded by their employers. We expect on-campus students will either self-fund or apply for assistantships through the normal campus and unit competitions for such funds.

Total Costs: Thus, total estimated increased costs over the current operations for the five-year period would be approximately **$285,000.**

B. Anticipated Income in First Five Years

Student Tuition: Numbers in the table below are based on the following assumptions: (a) the projected enrollments listed in Section III. D. will be achieved, (b) half of the graduate students each year will pay the e-rate for distance students and the other half on-campus will pay Maine in-state graduate tuition, (c) on-campus students will complete on average 15 credits per year (i.e. assumes completion in two years) and distance students will complete on average 9 credits per year, and (d) for rough and conservative estimation purposes the annual tuition and fee rates over the five-year period will be held constant. The results of this revenue computation over five years is as follows.

Year	Total # Students	On-Campus Students	Distance Students	Annual On-Campus Credits Per Student	Annual Distance Credits Per Student	On-Campus Income	Distance Income	Total for Year
2019-2020*	3	1	2	9	3	$4,351	$3,706	$8,057
2020 - 2021	10	5	5	15	9	$36,925	$28,485	$65,410
2021 - 2022	17	8	9	15	9	$59,080	$51,273	$110,353
2022 - 2023	25	12	13	15	9	$88,620	$74,061	$162,681
2023 - 2024	30	15	15	15	9	$110,775	$85,455	$196,230
						5-Yr TOTAL		$542, 731

* - students attend only second semester in the first year (9 credits on-campus and 3 credits by distance)

Notes: Amounts in the above table are based on the following rates and fees:

TUITION	Per Credit Hour	FEES		Per Semester	Per Credit
In-State Tuition	$439	**Unified Fee**	< 6 credits	$131	
E-Rate (Distance)	$549		6-11 credits	$400	
			12-15 credits	$980	
			16+ credits	$1006	
		Online Fee			$25

Example Computations for 2020-2021:
On-Campus: 5 students*[($439 tuition/cr*15cr/yr)+($400 + $400 unified fees)] = $36,925
Distance: 5 students*[($549 tuitn/cr*9cr/yr)+($131+$400 unifd fees)+(9cr*$25 online fees)] = $28,485

While some on-campus *Data Science and Engineering* graduate students may be involved in and supported through externally funded research assistantships, those potential revenues and expenditures are not addressed in this proposal.

C. Anticipated First Year Costs
The first-year costs could be the entirety of that listed under Section VI. A. or a subset. The most critical items to get the program off and running in the first year would be the Program Coordinator ($45,000) and the social media marketing costs ($8,000).

VII. Program Evaluation

Reviews of the overall graduate program and coursework will be overseen by the Data Science and Engineering Oversight Committee and the School of Computing and Information Science (SCIS). Teaching evaluations are accomplished online for each course near the end of each semester in SCIS. Summary results from these courses as well as all other graduate courses involved in the MS program will be requested regularly by the Oversight Committee and reviewed. Oversight Committee members will be encouraged to sit in on classes for observations as needed and as appropriate. If and when needed, corrective actions will be suggested.

Further, the SCIS Director or an assigned lead professor will be tasked with accomplishing both exit interviews (in person or by Zoom) and exit surveys just prior to graduation for each student graduating from the program. This typically occurs just prior to or during final exam week. The process is in place and followed for the SCIS undergraduate programs in Computer Science and New Media. It now will be extended as well to the graduate degree programs. The Oversight Committee will review these further results and discuss and recommend actions as appropriate.

The University of Maine is accredited by the New England Commission of Higher Education (NECHE) which imposes further data collection and assessment requirements (https://www.neche.org/resources/standards-for-accreditation/). Those standards and data collection requirements will be met as part of the ongoing assessment processes of the University. Further, the University of Maine mandates and accomplishes formal internal regular reviews of its units and programs. The Data Science and Engineering graduate programs will be included as well within these regular reviews.

In September 2021, the Oversight Review Committee will compile all of the assessment data gathered in the previous two years, document any actions taken during that time, and document admissions, enrollments, retention, and graduation numbers for the MS program. In consultation with all teaching and student advisor professors involved in the program and with the Director of SCIS, the Oversight Review Committee will accomplish an audit of the program. This report will be delivered to UMaine administrators as well as the UMS Vice Chancellor for Academic Affairs.