UNIVERSITY OF NORTH CAROLINA
REQUEST TO PLAN
A NEW DEGREE PROGRAM – ANY DELIVERY METHOD

THE PURPOSE OF ACADEMIC PROGRAM PLANNING: Planning a new academic degree program provides an opportunity for an institution to make the case for need and demand and for its ability to offer a quality program. The notification and planning activity described below do not guarantee that authorization to establish will be granted.

Date: September 2017

Constituent Institution: University of North Carolina at Chapel Hill

Is the proposed program a joint degree program? Yes____ No X

Joint Partner campus _____

Title of Authorized Program: Professional Science Master's in Data Science

Degree Abbreviation: MPS

CIP Code (6-digit): 11.0101 Level: B _____ M X I _____ D _____

CIP Code Title: COMPUTER AND INFORMATION SCIENCES, GENERAL

Does the program require one or more UNC Teacher Licensure Specialty Area Code? Yes_____ No _X_

If yes, list suggested UNC Specialty Area Code(s) here _____

If master's, is it a terminal master's (i.e. not solely awarded en route to Ph.D.)? Yes _X__ No____

Proposed term to enroll first students in degree program: *Term* Fall *Year* 2018

Provide a brief statement from the university SACSCOC liaison regarding whether the new program is or is not a substantive change.

Identify the objective of this request (select one or more of the following)

X Launch new program on campus
☐ Launch new program online; Maximum percent offered online _____
  ☐ Program will be listed in UNC Online
  ☐ One or more online courses in the program will be listed in UNC Online
☐ Launch new site-based program (list new sites below; add lines as needed)
  ☐ Instructor present (off-campus delivery)
  ☐ Instructor remote (site-based distance education)

Supply basic program information for UNC Academic Program Inventory (API) and UNC Online

Minimum credit hours required	30
Expected number of full-time terms to completion	2 semesters, 2 summer terms plus 3-credit “boot camp” course

CONTENTS

1. Review Status

a. List the campus bodies that reviewed and commented on this request to Plan proposal before submission to UNC General Administration. What were their determinations? Include any votes, if applicable.

This Request to Plan a Professional Science Master's (PSM) in Data Science has received support from the Data@Carolina Working Group at the University of North Carolina at Chapel Hill (UNC-Chapel Hill; **Table 1**). The Data@Carolina Working Group was formed in Summer 2014 as a replacement for an earlier informal Data Studies Working Group. The new group was established to extend the reach of the former group, in recognition of the fact that (1) the university's efforts to provide training in "data studies" are aimed at undergraduates, not graduate students and professionals (the target population for the proposed data science program); (2) the university's expertise and interest in "data" extend far beyond "data studies"; and (3) a focus on "data science" is more responsive to today's workplace demands.

With growing campus-wide support for a Data Science PSM, the need for a formal campus committee became clear, and a Data Science PSM Committee has since been formed (**Table 2**). This committee is co-chaired by Kevin Jeffay (Computer Science) and David Gotz (School of Information and Library Science). The Request to Plan also has been reviewed and approved by other PSM Committee members and by the Deans/chairs of the participating academic units: Department of Computer Science, Department of Mathematics, Department of Statistics and Operations Research, and the School of Information and Library Science.

Table 1. Data@Carolina Working Group

Name	Title and Affiliation
Stanley Ahalt, PhD	Professor, Department of Computer Science; Director, Renaissance Computing Institute (RENCI); Associate Director, NC TraCS Biomedical Service
Jay Aikat, PhD	Research Assistant Professor, Department of Computer Science; Chief Operating Officer, RENCI
Amarjit Budhiraja, PhD	Professor and Chair, Department of Statistics and Operations Research
Thomas Carsey, PhD	Thomas J. Pearsall Distinguished Professor, Department of Political Science; Director, Odum Institute for Research in Social Science
Greg Forest, PhD	Grant Dahlstrom Distinguished Professor of Mathematics

Jan Hannig, PhD	Professor, Department of Statistics and Operations Research
Kevin Jeffay, PhD	Gillian Cell Distinguished Professor and Chair, Department of Computer Science
Ashok Krishnamurthy, PhD	Adjunct Professor, Department of Computer Science; Deputy Director, RENCI; Director, NC TraCS Biomedical Service
Rich McLaughlin, PhD	Professor, Department of Mathematics
Peter Mucha, PhD	Bowman and Gordan Gray Professor of Mathematics
Barbara Wildemuth, PhD	Professor, School of Information and Library Science

Table 2. Data Science PSM Committee

Name	**Title and Affiliation**
David Adalsteinsson, PhD	Associate Professor, Department of Mathematics
Jay Aikat, PhD	Research Associate Professor, Department of Computer Science; Chief Operating Officer, RENCI
David Gotz (co-Chair)	Associate Professor, School of Information and Library Science; Assistant Director, Carolina Health Informatics Program
Jan Hannig, PhD	Professor, Department of Statistics and Operations Research
Kevin Jeffay, PhD (co-Chair)	Gillian Cell Distinguished Professor and Chair, Department of Computer Science
Shannon McKeen, MBA	Adjunct Professor, Kenan-Flagler Business School; Acting Director, National Consortium for Data Science
Peter Mucha, PhD	Bowman and Gordan Gray Professor of Mathematics
Barbara Wildemuth, PhD (former co-Chair, since retired)	Professor, School of Information and Library Science

b. Summarize any issues, concerns or opposition raised throughout the campus process and comment periods. Describe revisions made to address areas of concern.

This Request to Plan was originally conceived by the informal Data Studies Working Group described in §1.a[1]. Much enthusiasm exists for offering a PSM in Data Science; a few concerns raised early on regarding specific components of the program and available resources to implement the program have largely been addressed as described below.

Early in the planning process, the Data@Carolina Working Group expressed concerns about the feasibility of the capstone practicum, which is proposed to involve academic and non-academic (industry/non-profit/government/defense) co-mentoring teams. Specifically, the group was concerned about garnering sufficient interest and commitment from non-academic organizations to support the practicum and provide mentorship to students. To address those concerns, we have established an Industry Advisory Board (IAB) to oversee and implement the practicum, and we have secured commitment from non-academic partners, with representation across North Carolina and the nation (see §2.b.2, also see **Appendix 6**). These commitments will provide Data Science PSM students with the opportunity to work with leaders in multiple sectors of the economy and help solve real-world data challenges. We anticipate that we will procure additional commitments by leveraging existing relationship with IAB members and organizations such as the National Consortium for Data Science (NCDS) and the South Big Data Regional Innovation Hub (South BD Hub) (see §2.b.2), as well as through other outreach and networking activities.

The Data@Carolina Working Group also expressed minor concerns related to the modular courses, which will be offered as 0.5– to 3–credit hour courses. The Data Science PSM Committee will work with the College of Arts & Sciences to explore any accommodations to current practices regarding balanced teaching loads, to provide for a range in credit hours.

A final concern expressed by the Data@Carolina Working Group was related to faculty resources. This concern will be mitigated by leveraging existing courses and other institutional resources to the extent possible. Support for any additional faculty or institutional resources required to grow and evolve the program will largely come from market demand. This assertion is supported by a market analysis of employer demand for graduates of the proposed program and characteristics of competitor programs, conducted by the Education Advisory Board (EAB) on behalf of the Data Science PSM Committee (The Advisory Board Company 2016).[2] The Data

[1] Throughout the proposal, the section symbol '§' is used for cross-referencing within the text.

[2] As part of the initial planning process for the proposed Data Science PSM, the Data Science PSM Committee commissioned the Education Advisory Board (EAB), a division of The Advisory Board Company, to conduct a market analysis of employer demand and competitor program characteristics. The analysis included both quantitative data analysis and qualitative interviews with administrators of select competitor institutions, including: Georgia Institute of Technology, Georgia State University, Indiana University – Bloomington, Texas A&M University, Texas Tech University, University of California – Berkeley, Louisiana State University – Baton Rouge, Oregon State

Science PSM Committee has not received any other concerns related to the proposed Request to Plan. In fact, the committee has received widespread support for the program from across campus, including the academic units affiliated with the proposed program and those who have submitted letters of support (see **Appendix 6**). The committee expects to garner additional commitments as enthusiasm for the proposed program grows.

2. Description and Purpose

a. Provide a 250-word or less description of the proposed program, including target audience, delivery method, hours required, program core and concentrations (if applicable), post-graduate outcomes for which graduates will be prepared, and other special features. For programs with an online component, describe whether the delivery is synchronous with an on-campus course, partially synchronous, asynchronous, or other.

To begin to address the critical need for advanced training in data science in order to succeed in today's data-driven world, we propose an innovative, broadly applicable, team-based, 12-month, full-time (30-credit) ***Professional Science Master's in Data Science*** *program.* The program is designed specifically for professionals with 3+ years of work experience in the many fields with urgent needs for skilled data scientists, but it is relevant to recent college graduates. The program will begin in summer session two with a 3-credit, seven-day Data Science Essentials "boot camp" or course designed to provide remediation/refresher coursework and team building. Students will then complete a minimum of 24 credits of coursework in the fall and spring semesters. Modular core courses and electives in data science will be offered as 0.5– to 3–credit hour courses, modeled initially on existing course materials and workshops (see **Appendix 1**). Courses in professional skills (0.5 to 1.5 credit hours) will be offered through The Graduate School at UNC-Chapel Hill (see **Appendix 2**). Specialization will be offered as an option through completion of two additional courses within an academic unit of relevance to the student's practicum, such as environmental science, social science, public health, pharmacy, public policy, and city and regional planning. Importantly, the program concludes with a 3–credit hour capstone team-based practicum in which students will work on real-world data challenges under the mentorship of co-mentor teams drawn from academic and non-academic (industry/non-profit/government/defense) sectors and then prepare a final oral presentation and paper (see **Appendix 3**).

University, University of Wisconsin – Madison, University of Virginia, University of Central Florida, University of California – San Diego, and University of Washington. The EAB presented their findings to the Committee in the form of a Market Research Brief (The Advisory Board Company 2016). Many of those findings are incorporated within this Request to Plan.

b. How does the proposed program align with system, institutional and unit missions and strategic plans?

The proposed Data Science PSM will be collaboratively offered by several core units at UNC-Chapel Hill, briefly described below, with the Department of Computer Science serving as the central administrative unit:

- ***Department of Computer Science:*** The Department of Computer Science was established in 1964 as one of the first academic departments in the nation to focus exclusively on the then nascent field of computer science. The department currently has 32 tenured or tenure-track faculty, 29 adjunct or research faculty, and numerous postdoctoral fellows and visiting scholars. Computer Science aims to foster frontline research and provide innovative educational opportunities. The department offers Bachelor of Science, Bachelor of Arts, Master of Science, and Doctor of Philosophy degrees. Graduates of all programs are highly successful in finding employment in a variety of fields and organizations, including industry; indeed, the majority of master's graduates work in industries ranging from small start-ups to large, international corporations. Faculty research is focused on computer graphics, 3D imaging, robotics, applied engineering, networking, digital security, and bioinformatics and computational biology. Computer Science will contribute to the proposed program through its relevant coursework, theoretical and applied research, and collaborative work with industry.
- ***Department of Mathematics:*** The Department of Mathematics has 30.5 tenure-track faculty, with world renowned expertise in applied and computational mathematics, analysis, and algebra-geometry-topology. The department has a highly competitive graduate program, ranked 28th out of 134 ranked programs in the 2014 U.S. News & World Report rankings of graduate programs in mathematics. PhD graduates go on to postdoctoral fellowships at many of the best mathematics centers, and many eventually land in tenure-track positions at top-tier universities. The department's undergraduate program has grown dramatically in recent years, tripling in size in just five years and producing >140 mathematics majors per year. External research funding in Mathematics has grown 500% since 1998, when the applied mathematics program was established, and currently brings in greater than $5 million annually in grants and contracts. The department is distinguished by its faculty, with eight current or former NSF Career Award holders, two Fellows of the Society for Industrial and Applied Mathematics, nine Fellows of the American Mathematical Society, five invited speakers to the International Congress of Mathematicians, one member of the American Academy of Sciences, one term-distinguished professor, and seven chaired distinguished professorships. Mathematics will contribute to the proposed program through its course offerings and research expertise in applied mathematics.
- ***Department of Statistics and Operations Research (STOR)***: STOR is engaged in cutting-edge research, training, and teaching activities in data science, particularly with its intersections in the fields of mathematical and applied statistics, probability theory, optimization theory, and mathematical modeling of stochastic systems. The department's goals are to make fundamental advances in core knowledge within these fields and also to lead the

development of applications to problems arising from systems with uncertainty. For example, the stochastic modeling group has been leading the charge in health analytics; the department's statisticians have been making important contributions in genomics and bioinformatics; the optimization group has been involved with computational algorithms for large optimization problems; and probabilists within STOR have been engaged in large-scale challenges in fields that include biology, social networks, and communication systems. Graduates work in many diverse areas of industry and government, as well as serving on university faculties throughout the United States and abroad. STOR will contribute to the proposed program through its course offerings, experience with interdisciplinary research, and connections to a diverse array of government and industry leaders.

- ***School of Information and Library Science (SILS)***: One of the nation's top-ranked Schools by U.S. News & World Report (2017), SILS focuses on several key research areas: digital curation, human information interactions and the systems that support them, health information resources, librarianship for the 21st century, and social justice and equity issues in the information society. SILS has 30 full-time faculty members, and 11 of those faculty members serve as PIs on 15 active grants/contracts totaling $6.4 million in revenue. SILS offers five degree programs (at the undergraduate, master's, and doctoral levels) and several certificates. In addition to its existing degree programs, the school has proposed a PSM in Digital Curation, which is currently under review. Moreover, the school collaborates in several dual-degree and interdisciplinary programs, including the Biomedical and Health Informatics (BMHI) PSM program at UNC-Chapel Hill. SILS will contribute to the proposed program through its experience with PSM programs, coursework related to data science (including courses and expertise representing both technical and socio-cultural interests in the field), and the school's long-standing industry connections.

These academic units are all dedicated to advancing the field of data science and positioning UNC-Chapel Hill and the State of North Carolina as a hub of education and innovation in data science.

As noted, SILS is an active participating unit in the existing BMHI PSM program at UNC-Chapel Hill and has proposed a Digital Curation PSM program that is under consideration by the Board of Governors. It bears noting here the clear distinctions between these programs and the proposed Data Science PSM program. Participation in both degree programs aligns well with SILS' goal of educating professionals who can address issues of data quality and application of data to new societal challenges. The BMHI PSM program focuses on data originating in health/medical settings, including patient data and clinical research data. Graduates of the program are well-equipped to design usable systems in health/medical settings and to organize and manage health-related data. The proposed Digital Curation PSM program will focus on the management and stewardship of digital content, particularly documents. The process of digital curation ensures the longevity, authenticity, discoverability, renderability, understandability, and usability of such digital content. Graduates of the program will be equipped to manage digital content, and they will be competitive for positions such as digital media specialist, project archivist, and librarian for digital publishing, among others. The proposed Data Science PSM

program will consider data generated in a variety of domains (including, but certainly not limited to, the health/medical domain) and will focus on the application of analytic tools and approaches to transform data into actionable insight for decision making across a variety of domains. Graduates of the proposed program will be equipped to identify data sources for particular domain applications, select and apply tools and approaches for the management and analysis of the data, and guide decision makers in the interpretation and application of analytic results.

The proposed Data Science PSM aligns with the mission of UNC-Chapel Hill *to serve as a center for research, scholarship, and creativity and to teach a diverse community of undergraduate, graduate, and professional students to become the next generation of leaders*. The proposed program will equip the 21st-century workforce with the data science skills needed to harness the power of today's era of Big Data through data-driven insights and solutions.

The proposed Data Science PSM also aligns with the UNC System 2013-2018 Strategic Directions for *Our Time, Our Future*. Specifically, the proposed program aligns with the five core goals of the UNC System strategic plan, as detailed below.

(1) Set degree attainment goals that are responsive to state needs.

The proposed Data Science PSM targets current professionals with 3+ years of experience, as well as recent college graduates, who wish to receive advanced training in data science. As such, the program will reach a broad audience and help to position North Carolina as a data science hub. The program is directly responsive to the needs of employers throughout the state, as described in greater detail in §4.a.i.

(2) Strengthen academic quality.

UNC-Chapel Hill, the flagship of the UNC System, is widely regarded as a premiere institution, with a collaborative learning and research environment and access to nationally and internationally recognized faculty. These features will foster the success of the proposed Data Science PSM program by promoting the interdisciplinary collaboration required to train the next generation of experts in data science. As described elsewhere, courses will be offered by four different academic units. In addition, several other units at UNC-Chapel Hill will make contributions to the quality of these offerings, through infrastructure support for academic work and existing partnerships with off-campus stakeholders in the industry, non-profit, government, and defense sectors. This contribution is significant, as academic/non-academic partnerships are recognized as having the potential to produce far-reaching benefits for all stakeholders, especially in data- and technology-oriented fields such as data science (Tachibana 2013).

The Howard W. Odum Institute for Research in Social Science, directed by Dr. Thomas Carsey, supports the social science teaching and research mission at UNC-Chapel Hill. The institute operates a world-renowned data archive and is a leader in archive tool and support development. The archive was founded in the late 1960s and houses one of the oldest and largest collections of machine-readable data in the United States; many of these datasets are

available to students and researchers for additional analysis. In addition, the UNC Dataverse is open to researchers across disciplines, for deposit and reuse of research data. Odum also offers specialized training and consulting services on quantitative and qualitative data analysis methods, GIS and spatial analysis, and data management. These services will be available to students enrolled in the proposed PSM.

In addition, the proposed program's academic reach will be strengthened through strategic relationships with the Renaissance Computing Institute (RENCI) at UNC-Chapel Hill, the NCDS, and the NSF-funded South BD Hub. RENCI was launched in 2004 as a collaborative involving UNC-Chapel Hill, Duke University, North Carolina State University (NCSU), and the State of North Carolina. RENCI's current mission is "*to develop and deploy advanced technologies to enable research discoveries and practical innovations"*. RENCI achieves its mission by partnering with academic researchers, governmental policy makers, and industry leaders to engage in research and development in data science and cyberinfrastructure aimed at solving critical challenges in specific application areas. RENCI's emphasis on partnerships among academia, government, and industry, e.g., the NCDS and the South BD Hub, will help to ensure the success of the proposed PSM in Data Science.

The NCDS (www.data2discovery.org) was established by RENCI in August 2013 as a public-private partnership of leading universities, governmental agencies, and businesses drawn from around the country and dedicated to the advancement of data science. The mission of the NCDS is to solidify, accelerate, and advance the interdisciplinary field of data science and to serve as a vital forum for the broad community of scientists, business leaders, and policy makers. Data science education and training are core to the principles of the NCDS. PSM Committee member, Shannon McKeen, currently serves as Acting Director of the NCDS and Adjunct Professor in the Kenan-Flagler Business School at UNC-Chapel Hill. He has been and will continue to leverage these connections to garner commitments from industry leaders, governmental organizations, and the defense sector for the proposed practicum.

The NSF-funded South BD Hub (www.southbdhub.org), part of the National Big Data R&D Initiative, was launched in November 2015 as a collaborative initiative that is jointly led by RENCI/UNC-Chapel Hill and the Georgia Institute of Technology. The overall vision for the BD Hubs program is "*to create an agile and sustainable national Big Data innovation ecosystem that enables the United States to better leverage Big Data technologies and techniques in addressing societal challenges; increasing productivity and spurring economic development; enhancing scientific discovery; and providing for national defense and security"*.

The proposed program's relationships with RENCI, the NCDS, and the South BD Hub present an enormous opportunity for Data Science PSM students to engage with industry leaders and help solve real-world data challenges. Indeed, through these relationships, program participants have already secured commitments from multiple organizations for participation in the IAB and the planned capstone practicum (also see **Appendix 6**). The committed organizations/members include:

- Bank of America,
- Cisco Systems,
- Dell EMC,
- Deutsche Bank,
- LinkedIn Corporation,
- Median Technologies,
- MetLife,
- North Carolina Office of Science, Technology & Innovation, Department of Commerce,
- Quintiles,
- RTI International, and
- Target Corporation.

Ongoing outreach and networking by the Data Science PSM Committee is expected to yield many additional commitments. To point, we are engaging with key personnel at several military bases in North Carolina, and we are confident that we will receive commitments for participation in the IAB and the capstone practicum.

(3) Serve the people of North Carolina.

The RTP area is rapidly becoming a data science hub. IBM's 72,000–square foot "Cloud Resiliency Center", established in September 2014 (Smith 2014), provides just one example of international interest in the RTP area as a center of data-centric innovation. A joint comprehensive report by the North Carolina Science, Technology & Innovation Commerce and the NCDS indicates that industry investment in data science and technology within the RTP region and across the state has contributed to a growing need for advanced training in data science to support the region's "data economy" (Doron et al. 2016).[3] That same report includes the results of internet surveys, personal interviews, and composite data in support of the claim that across the state, demand for trained workers with skills in data science far exceeds supply, thus providing UNC-Chapel Hill the opportunity to serve as a statewide model for advanced data science training.

(4) Maximize efficiencies.

Program participants recognize the importance of stewardship of the resources entrusted to UNC-Chapel Hill. As such, the proposed Data Science PSM program will build on existing resources. In particular, modular courses in data science will be developed using existing course materials to the extent possible. Modular courses in professional skills will be offered through

[3] "NC has a big opportunity in data science and data analytics; it has universities and big companies, huge workforce."—Chris Estes, Director, PricewaterhouseCoopers and Former Chief Information Officer for the State of North Carolina (Doron et al. 2016).

The Graduate School's existing portfolio. Specialization courses will be offered through academic units of relevance to the student's practicum.

(5) Ensure an accessible and financially stable university.

The Data Science PSM Committee has developed a sustainability plan based on a tuition differential in order to ensure that the proposed program remains affordable and accessible, while also being fiscally viable. A premium tuition is essential to the success of the proposed program. This premium is in line with similar programs across the state and nation. (See §9.a.i for details.)

c. What student-level educational objectives will be met by the proposed program?

Students who complete this program will be able to:

(1) Apply advanced tools and techniques in data science to solve specific challenges in a specialty domain such as environmental science, social science, public health, pharmacy, public policy, or city and regional planning;
(2) Understand the social and ethical implications of data science applications;
(3) Perform effectively and professionally in team-oriented workplaces; and
(4) Compete for jobs in both academic and non-academic (industry/non-profit/government/defense) sectors.

The emergence of massive data collections (i.e., "Big Data") has ushered in a paradigm shift in the way scientific research is conducted and new knowledge is discovered (Schmitt et al. 2015). Specifically, the traditional scientific approach of observation-based hypothesis testing is rapidly being complemented and, in some areas, even replaced by data-driven approaches to knowledge discovery that rely less on hypothesis testing and more on hypothesis generation. Nearly all scientific domains and industries are moving toward this so-called "fourth paradigm" of data-intensive and data-enabled knowledge discovery (Hey et al. 2009). The shift involves traditional fields such as biomedical and health science, which has always had access to rich data sources but is now facing unprecedented computational and analytic challenges due to the availability of electronic medical records and health-related data repositories, as well as emergent fields such as environmental science, which has only recently had access to the wealth of distributed data available from sensors and satellites. Moreover, the social sciences are recognizing the power of data derived from social media, mobile devices, and "Smart & Connected Communities". Indeed, the wealth and diversity of data available for scientific research has yet to be fully appreciated. To point, the so-called "Internet of Things" is growing faster than the human population, with an estimated 50 billion Internet-connected devices, objects, and sensors by 2020 (i.e., >6 devices/person worldwide) (Evans 2011). These data sources will allow academic scientists and leaders in the industry, non-profit, government, and defense sectors to approach knowledge discovery in entirely new ways.

Advanced training in data analytics, while originally considered the solution to the challenges of Big Data, is now recognized as insufficient to meet the needs of today's employee. As recently as 2011, a McKinsey Global Institute Report predicted that by 2018, the United States would have a shortfall of 140,000 to 190,000 "deep" analysts and an additional shortfall of 1.5 million general analysts and managers with analytic expertise (Manyika et al. 2011). That same report predicted that investments in analytic talent and training would produce a greater than 60% increase in operating margins across industry sectors.

However, follow-up reports have since found that analytic skills alone are increasingly insufficient to harness the power of Big Data, with industry leaders reporting minimal return on investments in analytics, largely because analytic findings are too often not actionable (Callinan et al. 2014; Court 2015). In fact, even companies that specialize in the application of advanced analytics report a need for a new type of skilled worker. A 2016 Gartner report indicates that greater than 40% of these organizations note a lack of skilled data scientists as their top challenge (Kart et al. 2016).

The failure of analytics to guide decision making is driving a need for a new type of talent. McKinsey argues in favor of "translators" (Ariker et al. 2014), whereas General Assembly and Burning Glass (2015) propose the "hybrid" employee. Regardless of terminology, as envisioned by both groups, the skilled worker that is in demand today has: skills in all aspects of data science; professional skills aligned with workplace needs; and knowledge of a specific applied domain, whether in science, business, government, or another sector.

Business-Higher Education Forum and PricewaterhouseCoopers emphasize the need for *skills* as opposed to *degrees* in data science, which is a field that they define as being focused on *the extraction of "actionable knowledge" from data and analytics* (Fain 2017). Data science includes skills to: understand and evaluate data/metadata quality and validity (description/metadata, provenance, intellectual property, heterogeneous data types, and data management); store, access, and preserve data (data storage models and mechanisms, data access, data security, data preservation); analyze and visualize data (statistical analysis, data/text mining, machine learning algorithms, algorithmic pre-processing of data, visualization); evaluate, interpret, and apply analytic results and visualizations (result validation, interpretation, and implications); and consider ethical, legal, and social issues related to data access and use (privacy, intellectual property, security, and socially impactful uses of results, both negative and positive). Skills in data science are all considered within the context of specific applications or domain areas, where research questions and operational challenges are defined and solutions are implemented.

The proposed Data Science PSM program begins to address strong recommendations by the Business-Higher Education Forum and others to instill data science education throughout the US higher education system in order to close the gap between academic culture and training and employer demand (Fain 2017). The proposed program addresses the need for data science talent and skills by offering data-centered, team-based learning in data science coupled with

training in a select specialty domain, such as environmental science, social science, public health, pharmacy, public policy, or city and regional planning. The proposed curriculum is based on a new pedagogy for graduate education that Data@Carolina members developed as part of the planning for the proposed program: data-centered learning for the domain-data scientist (Aikat et al. 2017). The pedagogy is based on four tenets that committee members embrace:

(1) Graduate training must incorporate interdisciplinary training that couples data science with the domain sciences.
(2) Graduate training must prepare students for work in data-enabled teams.
(3) Graduate training must include education in teamwork and leadership skills.
(4) Graduate training must provide experiential training through academic/non-academic practicums and internships.

For the proposed Data Science PSM program, students will receive core data science training in computer and information science, statistics, and applied mathematics, as well as a grounding in the social and ethical implications of data science applications. Students also will complete a capstone practicum, during which they will engage in complex, real-world, data-driven problem solving under the mentorship of academic–non-academic (industry/non-profit/government/defense) co-mentor teams. Specialization will be offered through coursework in a field directly related to a student's practicum, such as environmental science, social science, public health, pharmacy, public policy, or city and regional planning. Additionally, students will receive training in professional skills. Graduates of this program will, therefore, have skills in data science, a specialty domain, teamwork, and professionalism, thereby equipping them with the expertise needed to be competitive for a broad range of job opportunities in today's data-driven workplace.

3. Student Demand

Provide documentation of student demand. Discuss the extent to which students will be drawn from a pool of students not previously served by the institution.

National student demand for data science–related programs such as the proposed one has been increasing. For instance, a nationwide search (March 2017) of Burning Glass' database[4] identified 423 institutions offering graduate and professional programs in *Computer Science* or *Computer and Information Science*. These programs conferred 15,702 degrees in 2014, representing a 35% increase since 2010. A similar nationwide search identified 133 institutions offering graduate and professional programs in *Statistics.* These programs conferred 2,524 degrees in 2014 (a 44% increase since 2010). A nationwide search under *Applied Mathematics* identified 110 institutions conferring 1,811 degrees in 2014 (a 55% increase from 2010).

[4] Note that Burning Glass does not currently provide the ability to search specifically for programs in *Data Science* or *Data Analytics*.

Evidence for national student demand also was apparent in the EAB report that was commissioned by the Data Science PSM Committee (The Advisory Board Company 2016). Specifically, the EAB found widespread student demand for enrollment in the master's-level data science programs at competitor institutions across the country. The EAB additionally found that many students who enroll in master's-level data science programs do so to secure career advancement or switch career tracks. At Georgia Institute of Technology, for instance, 30% to 40% of students enroll to increase the opportunity for career advancement, and 20% to 25% of students enroll to switch career tracks to more data science–oriented positions. The EAB predicts that the online version of the proposed Data Science PSM program, to be offered in year three, will prove attractive to students in both North Carolina and across the nation, including working professionals in regions with employer demand for master's-level data science professionals but without proximal training opportunities.

The success of NCSU's Master of Science in Analytics (MSA) program provides an indicator of *local student demand* for training in data science–related fields. The program received >1100 applications for the 2017 graduating class, and the number of applications has consistently increased since the program's inception. Yet, NCSU's MSA program is able to accept only 13% of applicants. One hundred thirteen students graduated from the class of 2016, and 95% of these graduates had job placement at the time of graduation, with a mean base starting salary of $93,250 plus an average signing bonus of $10,500. The proposed program is expected to be equally competitive with the MSA program at NCSU.

UNC-Charlotte's Data Science and Business Analytics PSM program also has witnessed an increase in student demand over the past few years. For instance, in 2014, the program enrolled 118 students; in 2016 (two years later), the program enrolled 150 students, a 27% increase.

The UNC-Chapel Hill academic units that are collaboratively offering the proposed Data Science PSM program have likewise experienced increased student demand for training in data science–related fields. For example, STOR has been challenged over the past decade by the rapid growth in its Mathematical Decision Sciences (MDS) undergraduate and MS programs. In the 2000-2001 academic year, the department had 10 undergraduate students majoring in MDS; by 2008-2009, the number of undergraduates had increased to 20 students; and by 2016-2017, the number had risen to an astounding ~300 students (a 30-fold increase between 2000 and 2016). The number of undergraduate students seeking an MDS minor was >100 in the 2016-2017 academic year. For the MS MDS program, the department currently receives ~500 applications and is able to accept only 20 to 25 students per year (~5% acceptance rate).

The Department of Mathematics also has experienced an increase in student demand for training and enrollment in data science–related courses. Over the past decade, the department has witnessed growth in the number of undergraduate majors, from ~100 to >400 currently (a 4-fold increase).

SILS likewise has experienced increased demand for training in data science. In particular, the school has witnessed increased student demand for *elective courses* in data science. For instance, INLS 541, "Information Visualization", was first offered in Spring 2013 and has regularly enrolled 15 to 25

students per year since. INLS 625, "Information Analytics", was first offered in Spring 2015 and currently enrolls 15 students per year. INLS 626, "Introduction to Big Data and NoSQL", was first offered in Fall 2013 and now regularly enrolls 15 to 25 students per year. INLS 641, "Visual Analytics" was first offered in Fall 2014 and currently enrolls 20 students per year. Additionally, INLS 756, "Data Curation and Management", first offered in Fall 2010, now regularly enrolls 15 to 20 students per year.

Student demand for training in the Department of Computer Science also has exploded over the past decade. In 2008, the department had <200 undergraduate majors in computer science; today, the department has >900 undergraduate majors (a 4.5-fold increase). Student demand for advanced training in computer science is also coming from outside science programs. Indeed, the department has faced tremendous pressure to accommodate undergraduate and, especially, graduate students from other departments. However, with limited resources, the Computer Science department typically is forced to restrict course enrollment to computer science undergraduate majors and graduate students.

Importantly, the proposed Data Science PSM program will be expanded in year three to include an online option. As noted in the EAB report (The Advisory Board Company 2016), an online option is expected to appeal to out-of-state students and working professionals located in geographical regions with high employer demand but without proximal training opportunities. Moreover, an online option would make the proposed program more competitive with existing programs at peer institutions.

The evidence provided above attest to national and local student demand for training in data science–related fields.

4. Societal Demand

Provide evidence of societal demand and employability of graduates from each of the following source types.

"A *shortage of job candidates with fluency in data science and analytics is among the nation's most yawning of skill gaps, one requiring substantial changes by higher education institutions and employers alike*" (Fain 2017). This is the central finding of a 2017 report from Business-Higher Education Forum, a nonprofit group of Fortune 500 CEOs and college leaders, and the analytics and consulting giant PricewaterhouseCoopers.

The EAB evaluated *statewide and national demand* for master's-level data science programs such as the proposed one (The Advisory Board Company 2016). Their report noted a nearly 60% overall increase in employer demand for master's-level data science professionals between July 2013 and December 2016 (**Figure 1**). Statewide employer demand increased 57% over that time period (548 to 862 job postings); and national employer demand increased 55% (23,770 to 36,919 job postings). Although statewide and national demand for master's-level data science professionals decreased 19% and 14%, respectively, between December 2015 and December 2016, the decrease was smaller

than the corresponding decrease in demand for all master's-level professionals (24% statewide, 17% national).

Beyond employer demand, data literacy is essential for competitiveness and competency in both the workplace and in life, as informed citizens. We are witnessing an undeniable explosion in data, with the "Internet of Things", "Smart & Connected Communities", and social media influencing every field of science and every aspect of people's lives. Without adequate training in data science, we risk

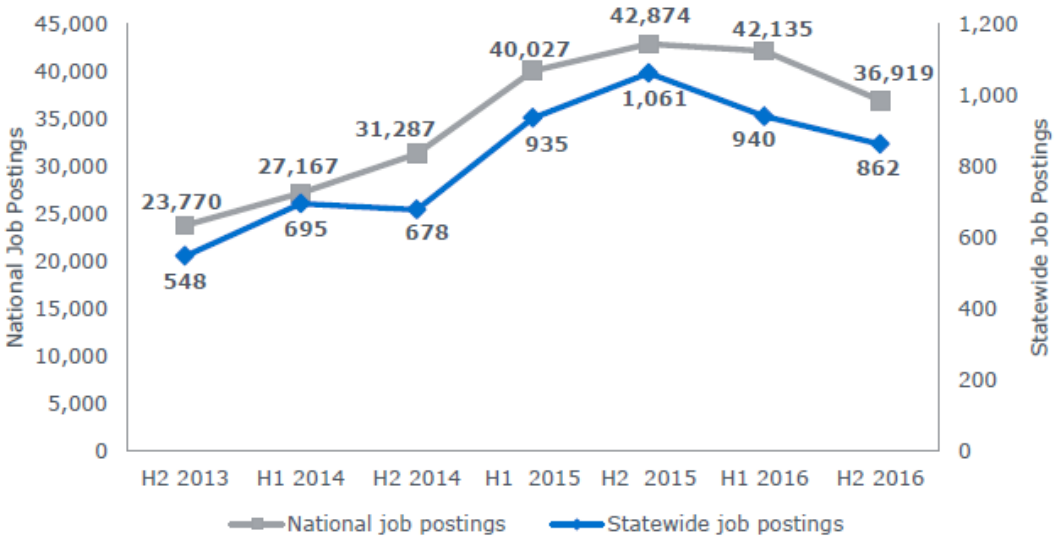


Figure 1. Statewide and national historical employer demand for master's-level data science professionals, July 2013 through December 2016. (Figure from The Advisory Board Company, 2016. Data from Burning Glass Labor/Insight™.)

creating a society that is not only uninformed, but also vulnerable to what has been called "weapons of math destruction", such as political polls and consumer surveys that produce spurious results and can influence human behavior and decision making if not interpreted properly (Zhang 2016).

The proposed Data Science PSM program will equip students with advanced skills in data science. The program will allow students to gain a competitive edge in both their professional and personal lives, and it will help foster data literacy across the state and the nation. The PSM model itself was created in response to both student and employer demand for employees with more advanced training than an undergraduate degree provides, but less training than a doctoral degree offers (Cassuto 2015). The model offers the flexibility to heed the mandate of groups such as the Business-Higher Education Forum for academic institutions of higher education to support training and the acquisition of skills in data science (Fain 2017).

Provided below is detailed evidence of societal demand for a Data Science PSM program.

a. Labor market information (projections, job posting analyses, and wages)

i. Specific to North Carolina

A 2012 survey by the UNC System found that approximately 90% of UNC System PSM alumni were employed at the time of the survey (~10% status unknown), and 74% reported employment in the State of North Carolina (Borbye 2014). More than 450 businesses, governmental agencies, and non-profit organizations have contributed to the UNC System PSM program by providing internships, employment, or other types of support.

A statewide search (February 2017) of Burning Glass' database indicates 802 job postings for employees with master's-level training *in data analysis and mathematics* over the past 12 months. These include jobs subcategorized as *data/data mining analyst* (250), *biostatistician* (228), *data scientist* (128), *statistician* (123), *security/defense intelligence analyst* (32), *geographer/GIS specialist* (21), *actuary* (18), and *mathematician* (2). The number of jobs in North Carolina is expected to grow at an average rate of 10.69% over the next 10 years, compared to 5.75% nationally. Nearly half of the open jobs require 3 to 5 years of experience, and ~30% require a graduate or professional degree. The top 12 state employers are Quintiles (54), Duke University (40), Oracle (29), Wells Fargo (24), UNC-Chapel Hill (18), Bank of America (17), PPD (14), TIAA-CREF (9), Carolinas Healthcare (8), Chiltern (8), First Citizens (8), and SAS Institute (8). The top ten job titles are Biostatistician (115), Data Analyst (84), Statistician (40), Data Scientist (38), SAS Programmer (23), Intelligence Analyst (22), Healthcare Data Analyst (20), Principal Biostatistician (20), Database Analyst (19), and Analytics Consultant (15).

As explained in §2.b.(3), the RTP region of North Carolina is rapidly becoming a hotbed of entrepreneurship in the data science sector. This will provide graduates of the proposed Data Science PSM program with a growing number of employment opportunities. Indeed, a joint report from the North Carolina Science & Technology Innovation Commerce and the NCDS argues that the state should "elevate the data economy to the top tier of economic development priorities" (Doron et al. 2016).[5] The same report cites multiple studies in support of this argument, including statistics showing that roughly 50 of the state's major businesses are currently advertising open positions for data scientists.

[5] "There's unlimited opportunity. North Carolina should be the Internet of Things/Data Science state."—David Houghton, Director, Bright Wolf

The EAB identified geographical clusters of job listings for master's-level data science professionals across the state, including RTP, Charlotte-Concord-Gastonia, Winston-Salem, and Greensboro-High Point (**Figure 2**).

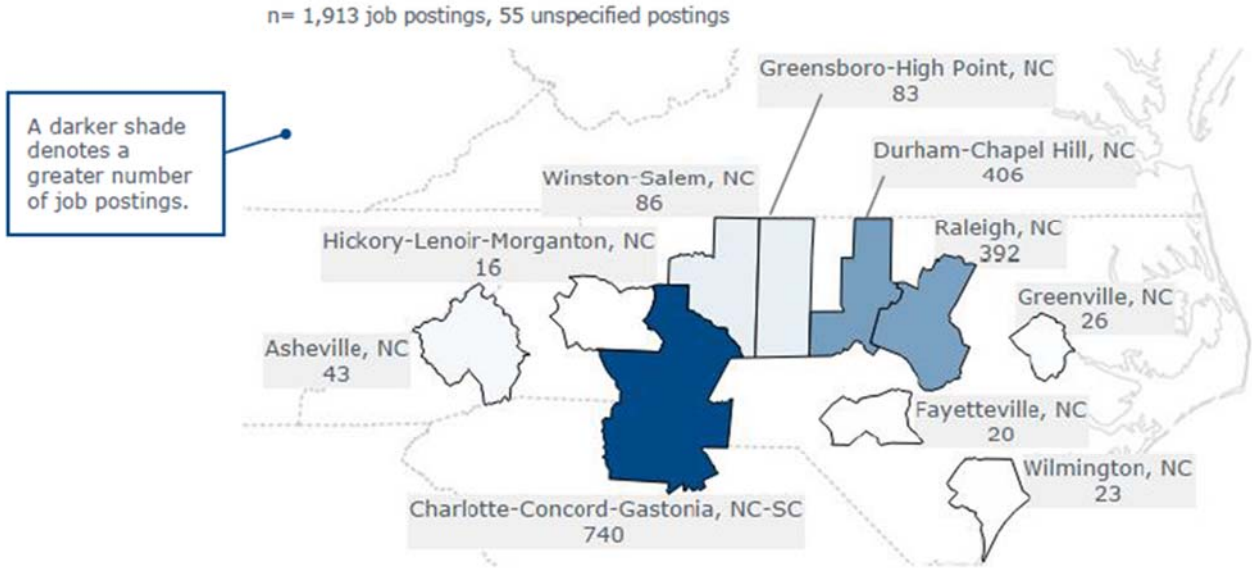


Figure 2. Statewide location of jobs for master's-level data science professionals, May 2016 through April 2017. (Figure from EAB report, The Advisory Board Company, 2016. Primary data source is Burning Glass Labor/Insight™.)

A search (February 2017) of the NC Department of Commerce's NCWorks Online data system using the term *data science* identified 116 open jobs, with titles that include Data Scientist, Data Science Machine Learning Expert, Data Science Consultant, Security Data Engineer, Government Marketing Research and Proposal Manager, Business Analyst, Strategic Marketing Analyst, Sales Operations Analyst, Senior Data Scientist for Geospatial Analytics, Pharmacy Analytics Intern, and Business Operations Manager for Policy Center of Excellence.

A search (February 2017) of the North Carolina Biotechnology Center's Biotech Jobs Board (http://directory.ncbiotech.org/) using the key word *data science* identified 481 open positions, with 316 of those located in the RTP region. A search on potential specialization fields of *environmental science*, *social science, public health*, *pharmacy*, *public policy*, and *city and regional planning* yielded 463, 391, 480, 32, 130, and 132 open positions, respectively. According to the center's website, North Carolina boasts greater than 600 life science companies, including 350 R&D organizations, 125 contract research and testing organizations, and 110 production and manufacturing organizations. Of note, life science jobs in North Carolina are growing at three times the national average, or 7% annually.

Graduates of the proposed Data Science PSM program will not be limited to jobs in the life sciences sector, however, but rather will be eligible for employment at numerous organizations. Relevant organizations that are either headquartered in North Carolina or

have regional representation include those listed in §1.b and §2.b.(2) that have already committed to the proposed program and many others. Specific examples are:

- Amazon,
- Bandwidth.com,
- Bank of America,
- Blue Cross Blue Shield North Carolina,
- Bright Wolf,
- ChannelAdvisor,
- Cisco Systems,
- CiTRIX,
- Cree,
- Dell EMC,
- Deloitte,
- Deutsche Bank,
- EMC,
- Epic Games,
- eTix,
- Fidelity Investments,
- GE,
- Google,
- HCL,
- IBM,
- iContact,
- Inmar,
- Lenovo,
- LinkedIn Corporation,
- Lulu,
- Median Technology,
- MetLife,
- Microsoft,
- NetApp,
- North Carolina Office of Science, Technology & Innovation, Department of Commerce,
- North Carolina Technology Association,
- ORACLE,
- Quintiles,
- RedHat,
- RTI International,
- SAS,
- ShareFile,

- The State of North Carolina, and
- Target Corporation.

ii. Available from national occupational and industry projections

National occupational projections also attest to the need for a Data Science PSM program.

A nationwide search (February 2017) of Burning Glass' database indicated 29,727 job postings for employees with master's-level training *in data analysis and mathematics* over the past 12 months. These included jobs subcategorized as *data scientist* (9376), *data/data mining analyst* (8826), *biostatistician* (3842), *statistician* (3504), *geographer/GIS specialist* (1500), *security-defense intelligence analyst* (1372), *actuary* (1075), and *mathematician* (232). The number of jobs is expected to grow at an average rate of 5.75% over the next 10 years. Nearly half of the open jobs require 3 to 5 years of experience, and ~30% require a graduate or professional degree. The 43,971 degrees conferred in *data analysis and mathematics* were awarded by programs with CIP codes for Computer Science, Computer and Information Sciences (General), Information Science/Studies, Information Technology, and Other (e.g., Mathematics [General], Statistics [General]). The top industries hiring qualified applicants with skills in these areas were professional/scientific/technical services, finance and insurance, manufacturing, and information. The top ten job titles were Data Analyst (4687), Data Scientist (2824), Biostatistician (1599), Statistician (1535), Intelligence Analyst (1079), Senior Data Scientist (1016), Machine Learning Scientist (548), Statistical Analyst (503), SAS Programmer (316), and Database Analyst (230).

The top 20 fastest growing occupations listed in the U.S. Bureau of Labor's Occupational Outlook Handbook (2015, the most recent year available) are classified as *statisticians* (#9), *operations research analysts* (#13), and *personal financial advisors* (#14)—careers in which graduate training in data science would allow for career advancement and a competitive advantage when applying for a job. The U.S. Bureau of Labor further projects that *computer and information technology* occupations will grow 12% from 2014 to 2024, faster than the average for all occupations, with an expected 488,500 new jobs over this period. Positions categorized as *computer and information research scientist* are projected to grow 11% from 2014 to 2024, with an expected 2,700 new jobs. The 2015 median annual wage for occupations within *computer and information technology* was $81,430 and that for *computer and information research scientist* was $110,620, which is higher than the median annual wage for all occupations of $36,200. These are fields in which data science is highly relevant.

As noted in §2.c, "hybrid" jobs or "translators" have emerged in recent years as a new job class that combines data science skills with traditional scientific or business skills (Ariker et al. 2014; General Assembly and Burning Glass Technologies 2015). More than 250,000 hybrid job openings were posted in 2014 in the United States, with annual salaries ranging from $65,000 to $111,000, which is well above the national average. Today's higher education system does not provide training to prepare the hybrid employee (Fain 2017); the

proposed Data Science PSM program—developed within the framework and tenets of the proposed new pedagogy of data-centered learning for the domain-data scientist (Aikat et al. 2017)—aims to fill that need.

b. Projections from professional associations or industry reports

The Big Data market is growing rapidly across industries. A 2014 SAS-sponsored EMA™/9sight Big Data research survey of 259 industry stakeholders focused on the integration of Big Data into industry portfolios. Respondents reported an average of 2.5 major projects within their Big Data portfolio. Nearly 65% of these Big Data projects are supported by a hybrid data ecosystem involving two to four platforms, thus demonstrating a need for a workforce with broad training in data science. A 2016 MarketsandMarkets report estimates that growth in the Big Data market will rise from $28.65 billion in 2016 to $66.79 billion by 2021 (a compound annual growth rate of 18.45%). The end users of Big Data solutions and services, as identified by the report, are diverse and include banking and financial services, government and defense, healthcare and life sciences, manufacturing, retail and consumer goods, media and entertainment, energy and utility, transportation, information technology and telecommunication, academia and research, and others. The MarketsandMarkets report also notes that vendors of Big Data solutions are increasingly turning to the global market to support their need for talent and access to data, thereby adding competitive pressures to train an adequate supply of skilled data scientists within the United States.

Despite the growth in the Big Data market, industries report a dearth of skilled data scientists. A 2016 Gartner report (Kart et al. 2016), based on a survey of ~600 advanced analytics practitioners, found that greater than 40% of organizations consider a lack of skilled data scientists as their top challenge. Of significance, this figure remains unchanged from the 2015 report, indicating a long-term unmet need for training in data science. Indeed, a survey by the consulting firm Accenture found that although >90% of their more than 1,000 clients are planning to hire employees with skills in data science, 41% cited a lack of talent as the key obstacle in hiring (Orihuela and Bass 2015). Likewise, McKinsey projects a 50% to 60% gap between supply and demand for data science talent by 2018 (Orihuela and Bass 2015). A Gallup poll conducted on behalf of Business-Higher Education Forum found that 69% of employers prefer candidates with skills in data science; yet, only 23% of college leaders affirm that their graduates will have the desired skills, and remarkably, a mere 21% report that their institutions require coursework in data science and analytics for undergraduate majors in *mathematics* and *statistics* (Fain 2017).

Industries such as retailing, consumer products, insurance, health care, aerospace, pharmaceuticals, finance, and manufacturing are all working to increase data science capabilities (Lohr 2015; Orihuela and Bass 2015). Technology giants such as Facebook and Google, large consulting firms such as PricewaterhouseCoopers, and small businesses of all types are actively seeking skilled data scientists (Gittlen 2012; Lohr 2015).

The specific skills that companies are seeking vary, although many are seeking candidates with both a degree in a data science–related field such as computer science or statistics and targeted training designed to apply those skills to solve specific business challenges; however, employers recognize that such candidates are difficult to identify (Gittlen 2012). Many organizations are forming data science teams to meet the growing demand for skills in data science (Linden 2015). A survey conducted jointly by MIT Sloan Management Review and SAS found that 63% of "mainstream" companies are providing formal on-the-job training to meet their needs in data science (Press 2015). These companies are training existing managers to develop analytic skills (49%) and training new data scientists in business fundamentals (34%), as well as ensuring that all employees are trained in teamwork. A 2017 Glassdoor® report places *data scientist* as the #1 job in demand in the U.S. (Leopold 2017). The same report found that data scientists rank the highest in job satisfaction rating (4.4 on a 5-point scale).

A recent search (March 2017) of LinkedIn Jobs using the keyword *data science* identified 6,706 entries. When restricted to North Carolina, LinkedIn Jobs identified 119 *data science* jobs. Another search (March 2017) of LinkedIn Jobs using the keyword *analytics* identified 88,430 entries. A comparable search roughly eight months previously (July 2016) identified 45,537 entries with a search of the same term. This represents a remarkable 94% increase in the number of *analytic*s jobs over an eight-month period. Of the 88,430 entries identified in the 2017 search, 4,079 were posted ≤1 day prior to the search. When the same search was restricted to North Carolina, 1,791 *analytics* jobs were identified, with 96 posted ≤1 day prior to the search.

Salaries are indicative of societal demand for data scientists, and industries are willing to pay high wages for skilled data scientists. O'Reilly's 2015 Data Science Salary Survey indicated a median salary of ~$104,000 for data scientists in the United States (King and Margoulas 2015). A salary and employment survey by Burtch Works recruiting found that the median base salary for entry-level data scientists was $91,000 nationwide, representing an 8% increase over the previous year, with bonuses adding $56,000 (Lohr 2015). A rolling Glassdoor® survey (sampled in December 2016) placed the median salary at ~$113,000 nationally and at ~$98,500 in Research Triangle Park. A 2015 Bloomberg report quoted a Stanford University Director as stating that in metro regions such as New York or Silicon Valley, starting salaries for a data scientist can exceed $200,000 (Orihuela and Bass 2015).

The EAB, in their report (The Advisory Board Company 2016), recommends that the Data Science PSM Committee promotes the proposed program as a pathway to higher than average salaries, with graduates of the program competitive for job listings with average annual salaries of $75,000 or more (**Figure 3**).

The evidence presented herein demonstrates strong societal demand for master's-level data science professionals.

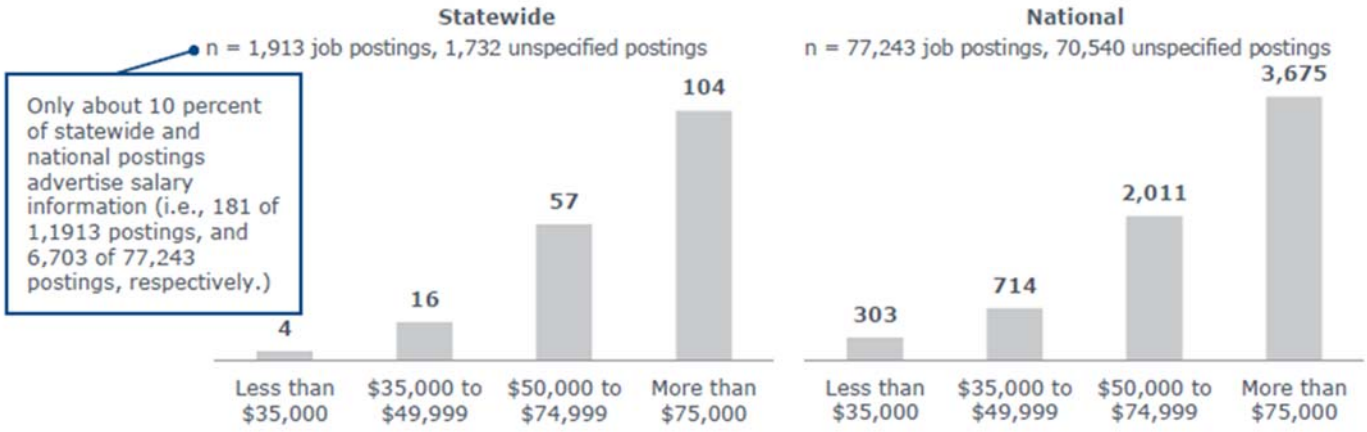


Figure 3. Statewide and national advertised salaries for master's-level data science professionals, March 2016 through February 2017 (Figure from EAB report, The Advisory Board Company, 2016. Primary data source is Burning Glass Labor/Insight™.)

c. Other (alumni surveys, insights from existing programs, etc.)

Job placement at graduation provides another indicator of societal demand. A recent national survey of PSM alumni, conducted by the Council of Graduate Schools with a grant from the Alfred P. Sloan Foundation, found that 78.1% of respondents were employed at the time of the survey (Allum 2012). Of those working full-time, nearly two-thirds (62.5%) reported earning greater than $50,000 annually, and 9.2% reported earning greater than $90,000 annually (Allum 2012). Moreover, respondents generally reported a high level of satisfaction with their training.

As described in §1.b.(3) and §3, the MSA program at North Carolina State University boasts a 95% job placement rate at graduation (class of 2016), with a mean starting salary of $93,250 plus an average signing bonus of $10,500.

The EAB's report noted that most employers are seeking master's-level data science professionals with previous work experience (~40% of statewide job listings; The Advisory Board Company 2016). Moreover, the same report found that many of our competitor institutions require prior work experience for admission to their graduate data science program. For example, Texas A&M University requires students to possess at least three years of work experience prior to admission and nearly 12 years of work experience on average. While the proposed program will not require prior work experience for admission, we will target professionals with three or more years of relevant work experience.

5. Unnecessary Duplication

a. List all other public and private four-year institutions of higher education in North Carolina currently operating programs similar to the proposed new degree program, including their mode of delivery. Show a four-year history of enrollments and degrees awarded in similar programs offered at other UNC institutions (using the format below for each institution with a similar program); describe what was learned in consultation with each program regarding their experience with student demand and job placement. Indicate how their experiences influenced your enrollment projections.

As part of the planning process for the proposed Data Science PSM, program participants conducted (in 2016) a comprehensive nationwide analysis of existing graduate and professional programs in data science or data science–related fields (e.g., analytics) among UNC-Chapel Hill's peer institutions from across the country. Nineteen of UNC-Chapel Hill's peer institutions have instituted successful data science or data science–related degree programs over the past several years. The existing programs vary in the number of required credit hours (range: 27 to 45) and expected time to completion (range: 9 to 31 months), as well as structure (full-time versus part-time, in-person versus online versus blended) and tuition and fees (range: $11,500 [Indiana University – Bloomington] to $65,000 [Carnegie Mellon]).

The identified programs also vary in their specific focus. Indeed, the analysis identified three general programmatic themes: *data science*, *data analytics*, and *business intelligence* (see **Appendix 4**). Programs categorized as data science tend to provide skills in applied data science and data analytics and include a focus on open source software engineering; data/metadata quality and validity; data storage, access, and preservation; data analysis and visualization; evaluation and interpretation of analytic results; and ethical, legal, and social issues/implications of data access and use, all within the context of a specific challenge as applied to a specific scientific domain. Programs categorized as data analytics tend to provide skills for targeted decision making and include a focus on data mining, data modeling, and data visualization to generate actionable knowledge from data. Programs categorized as business intelligence tend to provide skills for operations within industry or government and include a focus on the application of tools and approaches from data analytics and data science to improve business marketing, communications, and efficiencies. Programs in each category offer a mix of training in professional and technical skills; however, the emphasis of data science programs tends to be largely on technical skills, whereas that of business intelligence programs tends to be on professional skills, with data analytics programs focusing equally on professional and technical skills.

The UNC System currently offers 26 PSM programs across a variety of domains/disciplines. UNC-Chapel Hill, the flagship institution of the UNC System, offers only two PSM programs, one in BMHI and another in Toxicology; an additional proposal for a PSM in Digital Curation is currently under review. Only two of the 26 existing UNC System PSM programs are related to the

proposed Data Science PSM: NCSU's Professional MSA program and UNC-Charlotte's Data Science and Business Analytics PSM.

The three UNC System PSM programs differ greatly in primary emphasis, target student population, program structure, course offerings, intent of practicums or internships, and expected career trajectories of graduates (also see §5.c). As with the nationwide analysis of PSM programs in place at UNC-Chapel Hill's peer institutions, the three UNC System PSM programs can be distinguished by their distinct emphasis on one of three programmatic themes: *data science, data analytics,* or *business intelligence*. Specifically, NCSU's Professional MSA program focuses on data analytics for targeted decision making, and UNC-Charlotte's Data Science and Business Analytics PSM program focuses on business intelligence to support industry and government operations. In contrast, the proposed Data Science PSM is distinguished by its inherent focus on data science and data analysis as applied to a specific scientific domain. Furthermore, the proposed Data Science PSM is the only UNC System PSM program to place a heavy emphasis on applied data analysis and open source software engineering and tools, and it is the only program to engage the defense sector through connections with key military bases in North Carolina.

We recognize that two additional UNC System schools offer master-level programs in data science and data analytics; namely, Appalachian State University's Master of Science in Applied Data Analytics and UNC-Wilmington's Master of Science in Data Science. However, these are not PSM programs and thus are not comparable to the proposed Data Science PSM.

Provided below are the enrollment and history of degrees awarded for NCSU's MSA program and UNC-Charlotte's PSM program in Data Science and Business Analytics.

Institution: North Carolina State University

Program Title: Master of Science in Analytics

	2013-2014	2014-2015	2015-2016	2016-2017
Enrollment	85	86	115	120
Degrees awarded	79	86	113	TBD*

Institution: University of North Carolina – Charlotte

Program Title: Professional Science Master's in Data Science and Business Analytics

	2013-2014	2014-2015	2015-2016	2016-2017
Enrollment	0	118	147	150
Degrees awarded	0	30	61	TBD*

b. Identify opportunities for collaboration with institutions offering related degrees and discuss what steps have been or will be taken to actively pursue those opportunities where appropriate and advantageous.

Data Science PSM Committee members are engaged in ongoing outreach and networking, and those efforts are expected to yield many opportunities for collaboration with other academic and non-academic institutions and organizations.

For instance, NCSU and UNC-Charlotte, the two UNC System schools that offer PSM programs similar to the proposed Data Science PSM program, are members of both the NCDS and the South BD Hub. Moreover, PSM Committee member Shannon McKeen serves as Acting Director of the NCDS and interacts regularly with the organization's diverse membership. These existing relationships will foster collaboration among the three PSM programs.

Through SILS' participation, we have existing close relationships with UNC-Chapel Hill's BMHI PSM, proposed PSM in Digital Curation (recently by UNC's Board of Governors), and the Carolina Health Informatics Program, which offers an MPS in Biomedical and Health Informatics (CHIP), PhD in Health Informatics, Master of Science in Nursing, a variety of Certificate Programs, and a Duke/UNC-Chapel Hill Health Informatics Seminar Series. The Departments of Mathematics, Statistics and Operations Research, and Computer Science currently collaborate with the NSF-funded Duke/NCSU/UNC-Chapel Hill Statistical and Applied Mathematical Sciences Institute (samsi). SILS has Cooperative Archival MSLS/MA and MSIS/MA programs in place with NCSU's Department of Public History. Thus, the academic units proposing a Data Science PSM already have extensive experience in interdisciplinary and multi-institutional collaborations.

We will co-organize events and co-sponsor guest speakers of mutual interest, and we will share those presentations via teleconferencing, annual meetings of the program directors, and the sharing of data sets. We also will consider co-organizing a joint seminar series similar to the one in place for the Duke/UNC Health Informatics Seminar Series.

Additional opportunities for collaboration with existing programs likely will emerge during the planning process for the proposed Data Science PSM. We also anticipate establishing collaborations with Appalachian State University, through their Master of Science in Applied Data Analytics program, and UNC-Wilmington, through their Master of Science in Data Science.

c. Present documentation that the establishment of this program would not create unnecessary program duplication. In cases where other UNC institutions provide similar online, site-based distance education, or off-campus programs, directly address how the proposed program meets unmet need.

Two PSM programs related to data science/analytics have been established in North Carolina system schools: the MS in Analytics offered by North Carolina State University, and the PSM in

Data Science and Business Analytics offered by UNC-Charlotte. Although some similarities between these two programs and the proposed UNC-Chapel Hull PSM in Data Science exist (e.g., modular courses), the programs themselves are quite distinct.

Specifically, NCSU's Professional MSA program focuses on data analytics and targeted decision making and provides training in areas such as data mining, data modeling, and data visualization to generate actionable knowledge from data. UNC-Charlotte's Data Science and Business Analytics PSM program focuses on business intelligence to support operations within industry or government and provides training in the application of tools and approaches from data analytics and data science to improve business marketing, communications, and efficiencies. The proposed Data Science PSM, as the name suggests, focuses on data science and data analysis as applied to a specific scientific domain and provides training in data/metadata quality and validity; data storage, access, and preservation; data analysis and visualization; evaluation and interpretation of analytic results; and ethical, legal, and social issues/implications of data access and use. Furthermore, the proposed Data Science PSM is the only UNC System PSM program to place a heavy emphasis on open source software and tools. The proposed Data PSM also is the only UNC System PSM program to engage North Carolina's defense sector.

The key components of each of the three UNC System PSM programs are discussed below.

Primary emphasis of content: The names of each of the programs reveal their varying areas of emphasis. The focus of the program at NCSU is on data analytics, which concerns the discovery, interpretation, and communication of meaningful patterns in data through the application of data mining, data modeling, and data visualization to generate actionable knowledge from data. The program at UNC-Charlotte focuses largely on business intelligence, which involves the application of tools and approaches from data analytics and data science to support industry or government operations, including marketing, communications, and issues of efficiency. The focus of the proposed UNC-Chapel Hill program is broadly on data science and data analytics as applied to a specific scientific domain; as such, the proposed program concerns open source software engineering; data/metadata quality and validity; data storage, access, and preservation; data analysis and visualization; evaluation and interpretation of analytic results; and ethical, legal, and social issues/implications of data access and use, all within the context of a specific domain. Because of its unique emphasis on data science, the proposed PSM will complement the emphasis of the existing programs.

Content of required courses: The three UNC System programs also differ in the specific courses required to complete the curriculum. In the NCSU program, each course is organized into a sequence of short modules, with an overall emphasis on data analytics. The UNC-Charlotte program places a heavy emphasis on data analytics in various contexts (e.g., business analytics, consumer analytics); these analytics-focused courses comprise 18 of the 30 required credit hours. The unique curricular components of the proposed UNC-Chapel Hill program include: (1) greater emphasis on mathematical and statistical tools for data analytics; (2) emphasis on the social and ethical implications of data analytics; (3) coursework in professional skills (4.5 credit

hours required); and (4) an option for specialization in a specific scientific domain (e.g., environmental science, social science, public health, pharmacy, public policy, city and regional planning).

Program structure and length: The programs at all three schools require a minimum of 30 credit hours. The NCSU program is cohort-based; all 30 credit hours are in required courses (3 to 6 credit hours each), taken in lock-step over a 10-month period. The program offered by UNC-Charlotte is comprised of 24 credit hours of required courses and 6 credit hours of electives. Because UNC-Charlotte's students are part-time, the program requires a longer period of time to complete. The proposed UNC-Chapel Hill program is intended to begin in August and finish by mid-summer of the following year (i.e., requiring 12 months for completion). The coursework is comprised of courses ranging from 0.5 to 3.0 credit hours each, thus allowing students quite a bit of flexibility in their scheduling, relative to the other programs. The proposed Data Science PSM curriculum consists of 25.5 credit hours of required courses and 4.5 credit hours of electives. An online option, to be launched in year three, will allow the program to extend its reach and attract a diverse student body.

Role of a practicum/internship: The NCSU program includes a 12–credit hour practicum that is completed over both the fall and spring semesters and focused on the application of advanced analytics to large-scale research studies. The UNC-Charlotte program includes a 3–credit hour internship focused on a specific research project carried out under the mentorship of an industry partner; the internship is graded on a pass/fail basis. The proposed UNC-Chapel Hill program includes a 3–credit hour, capstone, team-based practicum, in which the students will work under the mentorship of a partner from the industry, non-profit, government, or defense sector.

Target student population: The program at NCSU targets working professionals and recent college graduates; for the current class, 45% of students have 3+ years of work experience, and 55% moved into the program immediately after receiving an undergraduate degree. NCSU's program is offered only as a full-time, in-person program. The program at UNC-Charlotte targets working professionals; as such, it is a part-time, in-person program. The proposed UNC-Chapel Hill program will target professionals with 3+ years of work experience, but we will also accept recent college graduates who have a relevant undergraduate degree. Although the proposed program will be oriented to full-time students, it was designed such that it can be completed by part-time students. Moreover, in year three, we expect to offer an online program in addition to the in-person option, which will greatly differentiate the proposed program from those in place at NCSU and UNC-Charlotte and promote UNC-Chapel Hill as the sole provider of an online master's-level data science program within the state. Moreover, the planned online program is expected to attract a more diverse student population than an in-person program, including both international and domestic students, as well as working professionals (The Advisory Board Company 2016).

Expected career trajectories of program graduates: Based on data from prior graduating classes, most graduates of the NCSU program accept jobs in analytics positions within a variety of organizations in the industry sector. Graduates of the program at UNC-Charlotte tend to accept jobs in similar positions. We anticipate that graduates of the proposed program will pursue careers as data scientists within a specific scientific domain (e.g., environmental science, social science, public health, pharmacy, public policy, city and regional planning) in the business, non-profit, government, or defense sector.

6. Enrollment

The enrollment projections below are based on current student enrollment in NCSU's MSA program, which was the first data science–related PSM program in the nation (http://analytics.ncsu.edu/). As noted in §3, NCSU's program was established in 2007, with 23 graduates in the inaugural 2008 class. By year 4, the program had 39 graduates in the 2011 class, and the class of 2016 included 113 graduates. Due to the growing desire for graduate training in data science, as described in §3, the Data Science PSM Committee anticipates similar (if not greater) enrollment numbers as those for NCSU's program.

Estimate the total number of students that would be enrolled in the program during the first year of operation and in each delivery mode (campus, online, site – add lines as needed):

*Delivery Mode*_campus__ *Full-Time* ___20_____ *Part-Time* ___0_____

Estimate the total number of students that would be enrolled in the program during the fourth year of operation and in each delivery mode (campus, online, site – add lines as needed):

*Delivery Mode*__campus_ *Full-Time* ___40_____ *Part-Time* ___0_____

*Delivery Mode*__online_ *Full-Time* ___40_____ *Part-Time* ___0_____

7. Resources

Will any of the resources listed below be required to deliver this program? (If yes, please briefly explain in the space below each item, state the estimated new dollars required at steady state after four years, and state the source of the new funding and resources required.)

a. New Faculty: Yes __X___ No ____
b. Faculty Program Coordination: Yes __X___ No _____
c. Additional Library Resources: Yes _____ No __X___
d. Additional Facilities and Equipment: Yes _____ No __X___

e. Additional Other Program Support: Yes __X___ No _____
(for example, additional administrative staff, new Master's program graduate student assistantships, etc.)

The proposed Data Science PSM program will leverage existing faculty, courses, and other institutional resources to the extent possible. However, the program will require a small amount of upfront funding to support a full-time program administrator and start-up efforts, such as program website creation and the preparation of the program application form, Plan of Study, course descriptions, etc. UNC-Chapel Hill's Executive Vice Chancellor and Provost, James W. Dean, Jr., has provided planning funds to cover these costs. In addition, it is expected that by the time it reaches its full capacity, the program will require approximately six additional faculty members. It is further expected that these faculty appointments will be distributed over the four core academic units that will be jointly administering the program. After program launch, program costs are expected to be derived from the program's tuition-based sustainability plan (described in §2.b.(5)).

8. Curriculum Leverage

Will the proposed program require development of any new courses? If yes, briefly explain.

The proposed program includes modular courses on data science and professional skills. Some of these are currently offered; others will be developed specifically for the proposed program but will be based on existing courses.

Core course modules in data science (**Appendix 1**) will be designed as 1.5– to 3–credit hour courses, modeled initially using materials derived from existing courses and workshops offered by participating academic units. The professional skills courses will be offered through The Graduate School's existing portfolio of 0.5– to 1.5–credit hour courses (**Appendix 2**). A 3–credit hour, capstone, team-based, academic–non-academic (industry/non-profit/government/defense) practicum with an oral presentation and written report will complete the curriculum requirements (**Appendix 3**). The specialty courses will comprise existing 3–credit hour courses in a field/department of relevance to a student's practicum. The overall goal is to provide a fast-paced, immersive, "real-world" learning environment; full-time students will be able to complete the program in 12 months.

In year three, an online program will be offered, in addition to the in-person program. This will require the development of new online courses. This planning will take place in close coordination with the University's ongoing efforts to extend its academic reach by offering graduate and undergraduate online courses.

9. Funding Sources

Does the program require enrollment growth funding in order to be implemented and sustained? If so, can the campus implement and sustain the program should enrollment growth funding be unavailable? Letters of commitment should be provided.

No, the program does not require enrollment growth funding.

a. For graduate programs only: Does the program require a tuition differential or program specific fee in order to be implemented and sustained?

i. If yes, state the amount of tuition differential or fee being considered, and give a brief justification.

A premium tuition of $14,000 per year in-state and $17,000 per year out-of-state will be charged above the regular full-time (9+ credit hours) graduate tuition, which for the 2017-2018 academic year is ~$14,000 for in-state residents and ~$33,000 for out-of-state residents. This rate (~$28,000 in-state, ~$50,000 out-of-state) was determined in consultation with The Graduate School and is consistent with that of similar PSM programs in North Carolina and across the nation. An analysis of tuition for comparable data science–related programs in the state (UNC System and private schools) showed that the proposed premium in-state rate is the highest among UNC System schools, but comparable to that of other institutions (**Figure 4A**); in contrast, the proposed out-of-state rate is slightly below average for the programs included in our analysis (**Figure 4B**).

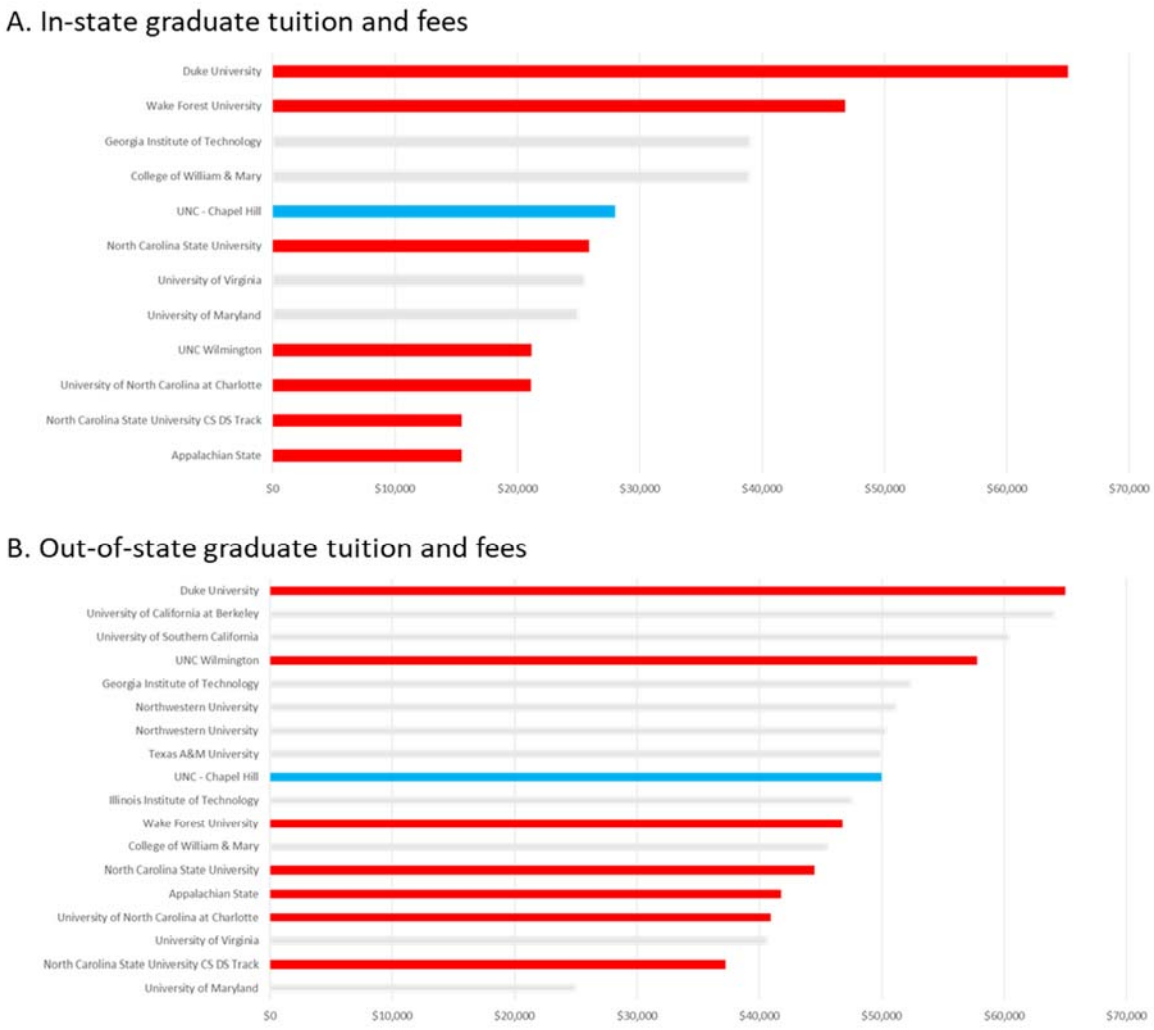


Figure 4. In-state (A) and out-of-state (B) graduate tuition and fees for comparative institutions.

Our proposed tuition rates also are comparable with the competitor institutions profiled by the EAB: in-state tuition for those institutions ranges from $16,200 to $39,000; out-of-state tuition ranges from $37,500 to $44,000. Several of the profiled institutions offer a single rate, ranging from $23,445 to $62,991. In addition, the proposed premium tuition is competitive with tuition for NCSU's 10-month Professional MSA program, which currently charges ~$26,000 for state residents and ~$45,000 for out-of-state residents. Program launch will require resources from The Graduate School, but we expect that the program will be sustained through additional revenue provided by the tuition differential.

ii. Can the campus implement and sustain the program if the tuition differential or program fee is not approved? Letters of commitment from the Chancellor and/or Chief Academic Officer should be provided.

As described in §9.a.1, the program's sustainability plan requires a tuition premium of $14,000 in-state and $17,000 out-of-state. To reach full capacity, we expect that the program will require approximately six additional faculty members. We expect that these

faculty appointments will be distributed over the four core units participating in offering the program. After program launch, program costs are expected to be derived from the premium tuition (described in §2.b.(5)).

10. For Doctoral Programs Only

a. Describe the research and scholarly infrastructure in place (including faculty) to support the proposed program.
b. Describe the method of financing the proposed new program (including extramural research funding and other sources) and indicate the extent to which additional state funding may be required.
c. State the number, amount, and source of proposed graduate student stipends and related tuition benefits that will be required to initiate the program.

Not applicable.

11. Contact

List the names, titles, e-mail addresses and telephone numbers of the person(s) responsible for planning the proposed program.

Kevin Jeffay, PhD
Chair and Gillian Cell Distinguished Professor
Department of Computer Science
College of Arts & Science, UNC-Chapel Hill
Phone: (919)-590-6238
Email: jeffay@cs.unc.edu

This request for authorization to plan a new program has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor: _____Date:_____

Chancellor (Joint Partner Campus): _____Date:_____

Appendix 1: Draft Core Data Science Courses

Required (18 credit hours)

Credits	Course title/description
1.5	**Social and Ethical Implications of Big Data Analytics (SILS, new)** Big data originates in a variety of venues; access to that data and ownership of it raise social and ethical issues. Data analytics produces results from which conclusions about society are drawn and acted upon; these uses also have social and ethical implications for practice. This course will focus on these issues that arise at both the beginning and the end of the process of data analytics.
3	**Fundamentals of Databases (INLS 523, 3 credits)** Design and implementation of database systems. Semantic modeling, relational database theory, including normalization, query construction, and SQL.
1.5	**Programming I (COMP; scripting/Python MATLAB)** An introduction to programming for data scientists. Fundamental programming skills, using Python. Problem analysis, algorithm design, plotting and visualizing data, with examples drawn from real-world data analysis tasks.
1.5	**Data-Driven Modeling and Scientific Computation I** Iterative methods, linear systems, curve fitting, linear algebra, eigenvectors, singular value decomposition, principal components analysis, independent component analysis, basics of image recognition.
1.5	**Regression** Basic regression models (linear regression), model fitting and diagnosis using R, high-dimensional models (LASSO), interpretation of results.
1.5	**GLM** Advanced modeling techniques for count data. Logistic regression. Fixed vs. random effects.
1.5	**Information Analytics (INLS 625, 3 credits)** Introduces analytical techniques to deal with very large datasets. Students will become familiar with predictive modeling, clustering, data mining and paradigms such as map-reduce.
1.5	**Visual Analytics (INLS 641, 3 credits)** Material includes foundational concepts and theories, seminal and recent research in the field, and hands-on experience with commonly used technologies.
1.5	**Bayesian Methods** Basics of Bayesian modeling. Selecting appropriate model and prior. Software implementations (WinBUGS, JAGS). Large scale data project.
1.5	**Machine Learning I (COMP)** Principles of artificial intelligence for inference and understanding. Classification, regression, support vector machines, hidden Markov models, principal component analysis, and deep learning. Applications to numeric and textual data for recognition, tracking, collaborative filtering and recommendation systems.

Credits	Course title/description
1.5	Data Curation and Management (INLS 756, 3 credits) Explores data curation lifecycle activities from design of good data, through content creator management, metadata creation, ingest into a repository, repository management, access policies, and implementation, and data reuse.

Electives (select 4.5 credit hours)

Credits	Course title/description
1.5	**Adv. Programming (COMP, data structures/algorithms)** The construction and use of data structures and their associated algorithms. Abstract data types, lists, stacks, queues, trees, and graphs. Sorting, searching, hashing and an introduction to numerical error control. Techniques of algorithm analysis and problem-solving paradigms.
1.5	**High-Performance Computing (COMP)** Principles and practices of parallel and distributed computing. Models of computation and programming models. Concurrent programming languages and systems. Architectures. Algorithms and applications.
1.5	**Introduction to Big Data and NoSQL (INLS 626, as is)** Information is being generated at an exponential scale in many areas, from astronomy to social networking to e-marketing. Processes for handling this data are data intensive, require heavy read/write workloads, and do not need the stringent ACID properties of relational databases. Several specific systems will be studied as examples.
3	**Web Databases (INLS 760, as is)** Explores concepts and practice surrounding the implementation and delivery of Web-enabled databases. Students will gain experience with and evaluate PC and Unix Web database platforms.
3	**Text Mining (INLS 613, as is)** This course will allow the student to develop a general understanding of knowledge discovery and gain a specific understanding of text mining. Students will become familiar with both the theoretical and practical aspects of text mining and develop a proficiency with data modeling text.
3	**Database Systems II: Intermediate Databases (INLS 623, as is)** Intermediate-level design and implementation of database systems, building on topics studied in INLS 523. Additional topics include MySQL, indexing, XML, and non-text databases.
3	**Information Assurance (INLS 566, as is)** Aspects of data integrity, privacy, and security from several perspectives: legal issues, technical tools and methods, social and ethical concerns and standards.
3	**Policy-Based Data Management (INLS 624, as is)** Students will develop policies for managing digital repositories and persistent archives. The rules will be implemented in the integrated Rule-Oriented Data System (iRODS), which organizes distributed data into shareable collections.
1.5	**Machine Learning II (STOR)** Linear discriminant analysis, nearest neighbors, and support vector machines; clustering algorithms; overfitting, estimation error, cross validation.

Credits	Course title/description
1.5	**Data-Driven Modeling and Scientific Computation II (MATH)** Time-frequency analysis, Fourier series, Fourier transforms, Wavelets, image processing, non-negative matrix factorization, compressed sensing, data assimilation methods, tensor decomposition.
1.5	**Network Analysis (MATH)** In a connected world, the study of networks provides a language for describing these connections and for describing the resulting impacts. With "nodes" representing actors of interest and "edges" connecting the nodes representing relationships, the concept of a network can be flexibly used across many applications.
1.5	**Object Oriented Data Analysis (STOR)** Analysis of complex data. Visualization by Projection. Principle component analysis, Connect Math to Graphics, PCA Redistribution of Energy. Curve estimation, Local linear smoothing and smoothing splines. Analysis of genetics data.
1.5	**Optimization (STOR)** Efficient Maximization: Linear and integer programing. The simplex method to solve linear programming. Inventory problems. Minimum cost network flow problems, with transportation problems. Integer programming modeling and the branch-and-bound method. Capital budgeting and fixed charge problems.
1.5	**Analytics in Health Sciences (STOR)** How students can use their methodological expertise in data analysis, optimization, simulation, and stochastic modeling in understanding and developing solutions for problems that typically arise within the healthcare system. The course will emphasize decision making as opposed to mere prescription and data analysis and cover a range of issues at different levels of the healthcare industry including disease treatment, operations, and public policy.
1.5	**Mathematical Topics in Data Analysis (MATH)** Possible topics for short modules includes topological data analysis and homology, compressed sensing, harmonic analysis, dimensional reduction, mode decomposition, equation-free modeling…

Additional Electives in Application/Domain areas

Credits	Course title/description
1	**Bioinformatics and Databases (BCB 712, as is)** This module introduces the basic information-science methods for storage and retrieval of biological information. Instructors review standard database types and their applicability to bioinformatics data generated in research laboratories. Students learn the role of metadata and ontologies as standardization mechanisms for providing interoperability between different information resource types such as genetic sequences, microarray maps, and journal articles.

Credits	Course title/description
1	Sequence Analysis (BCB 716, as is) This module is designed to introduce students to concepts and methods in the comparative analysis of nucleic acid and protein sequences, including sequence alignment, homology search, phylogenetics and genome assembly.

Appendix 2: Professional Skills Courses

Electives (select 4.5 credits)

710 Professional Communication: Writing (1.5 credit hours). Permission of The Graduate School. This writing-intensive, seminar-style course focuses on crafting effective email messages, short reports, and executive summaries in professional settings. Key topics include content selection, organization, accessibility, plain language, clarity and conciseness, tone, and graphic displays of information. This course requires a strong command of English.

711 Professional Communication: Presenting (1.5 credit hours). Permission of the Graduate School. This speaking-intensive, seminar-style course focuses on presenting complex topics using plain language in professional settings. Key topics include selecting and organizing content, developing audience-centered visual aids, incorporating storytelling, projecting a professional image, and managing Q & A. This course requires a strong command of English.

712 Role of Leadership for Professional Scientists and Potential to Build Effective Teams (1 credit hour). Leadership is a fundamental skill necessary for success as a professional scientist. Effective leadership begins with understanding your capacity to positively influence others. This course examines your current leadership style, team dynamics, change management, and intrapreneurial thinking (entrepreneurial thinking within organizations) for professional scientists.

713 Applied Project Management: Frameworks, Principles and Techniques (1.5 credit hours). Permission of the Graduate School. This course focuses on practical project management principles and techniques, demonstrating their effectiveness in the workplace. Key topics include frameworks and methodologies, planning and monitoring projects, risk management, stakeholder management, managing your team, and time and cost management. This course will include group work.

714 Introduction to Financial Accounting (1.5 credit hours). This course will teach the basics of Financial Accounting, including the Balance Sheet, the Income Statement, and the Statement of Cash Flows and Budgeting. The final presentation will incorporate financial skills and knowledge that can be used to support a future project proposal to business managers in an organization.

715 Building Your Leadership Practice (0.5 credit hour). Prerequisite, GRAD 712. Building on the development plan established in that program, students explore unique opportunities for practice available in their work environments. They will identify two areas of focus, based on their identified strengths and areas for growth, to map out a long-term practice schedule.

720 Team-based Consulting for Technology Commercialization (1 credit hour).* Permission of PSM Program Director is required. Course matches student teams with a small business that

has received a phase 1 SBIR. Students will be guided through development of a commercialization plan. Topics include: conducting market research and analysis of findings, intellectual property protection, team selection, and business model alternatives.

725 Master of Professional Science Seminar Series (1 credit hour). Intended for M.P.S. students. Emphasis on professional skills and career development, weekly presentations by invited professionals about the nature, challenges, and rewards of their chosen careers. Group assignments will require integration of ideas and concepts toward solving a problem, followed by in-class presentations and discussions.

*In GRAD 720 is not being offered, students may enroll in MBA 848A/B, “Launching the Venture (Opportunity, Feasibility, Business Planning, Finances)”.

Appendix 3: Capstone Practicum

Capstone Practicum (3 credit hours). Students will complete a capstone team-based practicum during their final Summer session. The practicum will be related to the student's area of specialization. The student's primary faculty advisor and program staff will work to identify an appropriate internship mentor drawn from the industry, non-profit, government, or defense sectors. Committed organizations include Bank of America, Cisco Systems, Dell EMC, Deutsche Bank, LinkedIn Corporation, MetLife, Median Technologies, North Carolina Office of Science, Technology & Innovation, Department of Commerce, Quintiles, RTI International, and Target Corporation. In such sites, students will work on real-world data challenges under the mentorship of co-mentor teams. A paper and oral presentation will be prepared and presented to describe the practicum experience, findings, and outcomes.

Appendix 4: Analysis of Existing Data Science–related PSM Programs, Nationwide

	Data Science	Data Analytics	Business Intelligence
Description	Provides skills for applied data science and data analytics; includes a focus on skills in open source software engineering; data/metadata quality and validity; data storage, access, and preservation; data analysis and visualization; evaluation and interpretation of analytic results; and ethical, legal, and social issues/implications of data access and use	Provides skills for generating actionable knowledge from data; includes a focus on data mining, data modeling, and data visualization	Provides skills for applying tools and approaches from data analytics and data science to support industry or government operations; includes a focus on marketing, communications, and efficiency
Typical Position	Data Scientist, Statistician	Data Analyst, Quantitative Analyst	Business Analyst, Marketing Analyst
Position Skills	Math (e.g. linear algebra, calculus and probability)	Statistical tools and packages (e.g. SPSS)	Analytic Problem-Solving (i.e., employing best practices to analyze large amounts of data while maintaining intense attention to detail; using requirements and systems analysis to dissect a complex business problem and create unique solutions)
	Statistics (e.g. hypothesis testing and summary statistics)	R and/or SAS languages	Effective Communication: Using reports and presentations to explain complex technical ideas and methods to an audience of laymen.
	Machine learning tools and techniques (e.g. k-nearest neighbors, random forests, ensemble methods, etc.)	Data warehousing and business intelligence platforms	Creative Thinking: Questioning established business practices and brainstorming new approaches to data analysis.
	Software engineering skills (e.g. distributed computing, algorithms and data structures)	SQL databases and database querying languages	Industry Knowledge: Understanding what drives your chosen industry and how data can

			contribute to the success of a company/organization strategy.
	Data visualization (e.g. ggplot and d3.js) and reporting techniques	Programming (e.g. XML, Javascript or ETL frameworks)	Technical Expertise: Using one's knowledge of big data, computer programming, systems engineering, database management, etc. to achieve strategic business goals.
	Unstructured data techniques	Database design	Business Acumen: Understanding how individual processes and technologies relate to the whole of the business; monitoring industry trends and predicting new developments.
	Python (most common), C/C++ Java, Perl	Data mining	
	Big data platforms like Hadoop, Hive & Pig	Data cleaning and munging	
	Cloud tools like Amazon S3	Data visualization and reporting techniques	
Mix	30/70	50/50	70/30
Professional/Technical			
Home Departments	Graduate School, Computer Science, Engineering	Engineering, Graduate School, Business	Business
Avg Credit Hours	33	34	34
Avg Price	$37,903	$36,490	$35,569
Examples	**Illinois Institute of Technology**	**North Carolina State University**	**University of North Carolina at Charlotte**
	University of Virginia	**Georgia Institute of Technology**	**University of Southern California**
	University of North Carolina at Charlotte	**Texas A&M University**	**Wake Forest University**
	University of California at Berkeley	**University of Maryland**	**College of William & Mary**
	Carnegie Mellon University	**Northwestern University**	

Appendix 5: References

Aikat J, Carsey T, Fecho K, Jeffay K, Krishnamurthy A, Mucha PJ, Rajasekar A, Ahalt S. Scientific training in the era of big data: a new pedagogy for graduate education. Big Data. 2017;5(1):12–18.

Allum JR. Outcomes for PSM alumni: 2011/12. Washington, DC: Council of Graduate Schools, 2012. http://www.cgsnet.org/ckfinder/userfiles/files/PSM_E_and_D_Outcomes_Report_2012_final.pdf.

Ariker M, Breuer P, McGuire T. How to get the most from big data. McKinsey Global Institute Report. McKinsey & Company, 2014. http://www.mckinsey.com/insights/business_technology/how_to_get_the_most_from_big_data.

Borbye L. Professional Science Master's. Meeting employers' needs in North Carolina. 10 year legacy. Raleigh, North Carolina: The Graduate School, NC State University, 2014. https://www.northcarolina.edu/sites/default/files/documents/10_year_legacy_psm_report_with_appendices.pdf.

Burrowes J, Young A, Restuccia D, Fuller J, Ramam M. Bridge the gap: rebuilding America's middle skills. Accenture, Burning Glass Technologies, Harvard Business School, 2014. https://www.accenture.com/us-en/insight-bridge-gap-rebuilding-americas-middle-skills.aspx.

Callinan P, Edelman D, Hieronimus F. Marketing in three dimensions. McKinsey Global Institute Report. McKinsey & Company, 2014. http://www.mckinseyonmarketingandsales.com/marketing-in-three-dimensions.

Capital One and Burning Glass Technologies. Crunched by the numbers: the digital skills gap in the workforce. Burning Glass Technologies, 2015. http://burning-glass.com/research/digital-skills-gap/.

Cassuto L. A degree of uncommon success. How academe and outsiders collaborated to shape the 'professional science master'. The Chronicle of Higher Education. June 29, 2015. http://chronicle.com/article/A-Degree-of-Uncommon-Success/231199.

Court D. Getting big impact from big data. McKinsey Global Institute Report. McKinsey & Company, 2015. http://www.mckinsey.com/insights/business_technology/getting_big_impact_from_big_data.

Doron S, McKeen S, Leonchuk L, Knowles D, Hardin J. NC in the next tech tsunami: navigating the data economy. A report from the NC Science, Technology & Innovation Commerce and the National Consortium for Data Science. Report, November 2016. https://www.nccommerce.com/Portals/6/Documents/Resources/NC%20Big%20Data%20Report.pdf .

Education Advisory Board (EAB), a division of The Advisory Board Company. Market Research Brief. Market demand for a Professional Science Master's in Data Science. Analysis of employer demand and competitor program characteristics. The Advisory Board Company, 2016.

Enterprise Management Associates™ (EMA™) and 9sight Consulting. Big Data: operationalizing the buzz. EMA Inc. and 9sight Consulting, 2014. http://www.sas.com/en_is/whitepapers/ema-operationalizing-the-buzz-big-data-107198.html.

Evans D, on behalf of Cisco Internet Business Solutions Group (IBSG). (April 2011). The Internet of Things. How the next evolution of the Internet is changing everything. Cisco, April 2011. http://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf.

Fain P. Data science disconnect. INSIDE HIGHER ED. March 30, 2017. https://www.insidehighered.com/news/2017/03/30/report-urges-data-science-course-work-all-undergraduates-close-growing-skills-gap.

Fenwick TJ. Expanding conceptions of experiential learning: a review of the five contemporary perspectives on cognition. Adult Education Quarterly. 2000:50(4):243–272. http://aeq.sagepub.com/content/50/4/243.

General Assembly and Burning Glass Technologies. Blurring lines: how business and technology skills are merging to create high opportunity hybrid jobs. General Assembly + Burning Glass Technologies, 2015. http://burning-glass.com/research/hybrid-jobs/.

Glassdoor®. Rolling Survey of Data Scientists. Glassdoor, Inc. https://www.glassdoor.com/Salaries/data-scientist-salary-SRCH_KO0,14.htm.

Glittlen S. Could data scientist be your next job? The definition of a data scientist varies, but no matter how it's defined, the skills are in demand. NETWORKWORLD. June 4, 2012. http://www.networkworld.com/article/2188925/infrastructure-management/could-data-scientist-be-your-next-job-.html.

Hey T, Tansley S, Tolle K (Eds.). The Fourth Paradigm. Data-intensive scientific discovery. Seattle, Washington: Microsoft Corporation, 2009. http://research.microsoft.com/en-us/collaboration/fourthparadigm/.

Kart T, Linden A, Sallam RL, Tohamy N, Krensky P. Cool vendors in data science, 2016. Gartner, Inc., 2016.

King J, Magoulas R. 2015 Data Science Salary Survey. O'Reilly Media, September 23, 2015. https://www.oreilly.com/ideas/2015-data-science-salary-survey.

Leopold G. Demand, salaries grow for data scientists. *datanami*. January 24, 2017. https://www.datanami.com/2017/01/24/demand-salaries-grow-data-scientists/.

Linden A, Kart L, Randall L, Beyer MA, Duncan AD. Staffing data science teams. Gartner, Inc., 2015.

Lohr S. Less noise but more money in data science as more businesses hire. *The New York Times*. April 28, 2015. https://bits.blogs.nytimes.com/2015/04/28/less-noise-but-more-money-in-data-science/?_r=0.

Manyika J, Chui M, Brown B, Bughin J, Dobbs R, Roxburgh C, Byers AH. Big data: the next frontier for innovation, competition, and productivity. McKinsey & Company, 2011. http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation.

MarketsandMarkets. Big Data market: global forecast to 2021. MarketsandMarkets, 2016. http://www.marketsandmarkets.com/Market-Reports/big-data-market-1068.html.

NC Tower. http://nctower.com/.

NCWorks Online. https://www.ncworks.gov/vosnet/Default.aspx.

Orihuela R., Bass D. Help Wanted: Black Belts in Data. Bloomberg Businessweek, June 4, 2015. http://www.bloomberg.com/news/articles/2015-06-04/help-wanted-black-belts-in-data.

Press G. The supply and demand of data scientists: what the surveys say. Forbes. April 30, 2015. https://www.forbes.com/sites/gilpress/2015/04/30/the-supply-and-demand-of-data-scientists-what-the-surveys-say/#87071386b902.

Rappa M. Master of Science in Analytics. April 2014. analytics.ncsu.edu/reports/msa.pdf.

Schmitt CP, Cox S, Fecho K, Idaszak R, Lander H, Rajasekar A, Thakur S. Scientific discovery in the era of big data: more than the scientific method. RENCI White Paper, Vol. 3, No. 6. North Carolina: RENCI, University of North Carolina at Chapel Hill, 2015. doi: 10.7921/G0C82763. http://renci.org/wp-content/uploads/2015/11/SCi-Discovery-BigData-FINAL-11.23.15.pdf.

Smith R. IBM opens 'cloud computing' data center in RTP. *WRAL TechWire.* September 22, 2014. wraltechwire.com/ibm-opens-massive-cloud-computing-data-center-in-rtp/14003590/.

Tachibana C. Opening industry-academic partnerships. Science. April 12, 2013. https://www.sciencemag.org/careers/features/2013/04/opening-industry-academic-partnerships.

Thibodeau P. Career alert: a Master of Analytics degree is the ticket – if you can get into class. *Computerworld*. April 24, 2014. www.computerworld.com/s/article/9247861/Career_alert_A_Master_of_analytics_degree_is_the_ticket_if_you_can_get_into_class.

United States Department of Labor. Bureau of Labor Statistics. Occupational Outlook Handbook. Published: December 17, 2015. http://www.bls.gov/ooh/.

U.S. News & World Report. 2014 Mathematics Ranking. U.S. News & World Report LP, 2014. https://www.usnews.com/best-graduate-schools/top-science-schools/mathematics-rankings.

U.S. News & World Report. 2017 Library and Information Studies Ranking. U.S. News & World Report LP, 2017. https://www.usnews.com/best-graduate-schools/top-library-information-science-programs/library-information-science-rankings?int=a31a09&int=a31a09&int=a31a09.

Zhang C. Cathy O'Neil, author of 'Weapons of Math Destruction,' on the dark side of big data. *Los Angeles Times*. December 30, 2016. http://www.latimes.com/books/jacketcopy/la-ca-jc-cathy-oneil-20161229-story.html.

Appendix 6: Letters of Support

1. Gayle S. Bieler, Director, Center for Data Science, RTI International
2. Mirsad Hadzikadic, Executive Director, Data Science Initiative, and Professor, Department of Software and Information Systems; Director, Complex Systems Institute, College of Computing and Informatics, UNC Charlotte
3. John W. Hardin, Executive Director of the Office of Science, Technology & Innovation, North Carolina Department of Commerce
4. Jeanne Hecht, Chief Operating Officer, Median Technologies
5. Javed Mostafa, Director, Carolina Health Informatics Program, and Professor, Biomedical Research Imaging Center and Information Science, University of North Carolina at Chapel Hill
6. Gary Shorter, Head of Cognitive and Automation Solutions, Quintiles IMS R&D Solutions
7. Chris Clemons, Senior Associate Dean for Natural Sciences, UNC College of Art & Sciences
8. Time Elston, Director, Curriculum in Bioinformatics and Computational Biology

RTI INTERNATIONAL
3040 E. Cornwallis Road • PO Box 12194 • Research Triangle Park, NC 27709-2194 • USA
Telephone +1.919.541.6000 • Fax +1.919.541.5985 • www.rti.org

March 27, 2017

Dear Dr. McKeen:

As RTI International's Director of the Center for Data Science, I am acutely aware of the value of and need for technically trained data science professionals who understand both business and research needs in an increasingly digital world. RTI has a broad set of current needs, and we anticipate additional needs for new employees (entry level through senior level) who understand not only the current tools of Data Science but also the problem-solving, statistics, predictive modeling, data visualization, and coding skills necessary to help RTI be competitive in a big data research world. RTI is pleased to be part of the proposed Data Science PSM at UNC Chapel Hill Industrial Advisory Board (IAB) and fully support the launch of the program. I believe the program and its graduates can help fill RTI's needs and is necessary to meet the growth opportunity for North Carolina employers.

Please let me know if you have questions.

Gayle S. Bieler
Director, Center for Data Science
RTI International
919-597-5131
gbmac@rti.org
www.rti.org/datascience

9201 University City Boulevard, Charlotte, NC 28223-0001

June 20, 2017

Dr. Kim Van Noort
Vice President for Academic Programs, Faculty and Research
UNC General Administration
Chapel Hill, NC

Dear Dr. Kim Van Noort,

The Graduate School at the University of North Carolina Charlotte and the Data Science and Business Analytics Professional Science Master's Degree program (DSBA PSM) support UNC Chapel Hill's request to plan a Professional Science Master's in Data Science program (Data Science PSM).

UNC Charlotte has a track record of collaboration with UNC Chapel Hill in Data Science including membership in the National Consortium for Data Science (NCDS) and collaboration on the North Carolina Data Science and Analytics (DSA) Initiative. The demand for data science skills in North Carolina will grow. In a recent survey of North Carolina employers, a shortage of applicants and a lack of adequate training in candidates were two of the top three challenges identified as barriers to hiring data professionals [1]. Finding qualified Data professionals is also a national challenge; according to Market Demand Study conducted by the Educational Advisory Board (EAB) found a 57% increase in demand for Data Science Professionals in North Carolina and a 55% increase in demand nationally. Qualified applications to the DBSA PSM are increasing and exceed the current spots at UNC Charlotte. Having a complementary program in Chapel Hill will be good for the state's economy.

Furthermore, the DSBA PSM prepares students for a variety of data science and analyst jobs, our students tend to graduate to jobs in financial services, energy, retail and healthcare. The proposed Data Science PSM will target students interested in environmental science, social science, public health, pharmacy, public policy, and city and regional planning.

UNC Charlotte looks forward to working with the Data Science PSM to create a pipeline of data science education and literacy across the state as outlined in the recent North Carolina Department of Commerce's report, "Opportunities in the Data Economy."

Sincerely,

Mirsad Hadzikadic

Mirsad Hadzikadic, Ph.D.
Executive Director, Data Science Initiative
Professor, Department of Software and Information Systems
Director, Complex Systems Institute
College of Computing and Informatics
UNC Charlotte, Charlotte, NC 28223

ROY COOPER
Governor

ANTHONY M. COPELAND
Secretary

DR. JOHN HARDIN
Executive Director

Dr. Kim Van Noort
Vice President for Academic Programs and Instructional Strategy
University of North Carolina (UNC)

Dear Dr. Van Noort,

As Executive Director of the Office of Science, Technology & Innovation (OSTI), part of the North Carolina Department of Commerce, I offer my unequivocal support for the establishment of UNC-Chapel Hill's Professional Science Master's in Data Science. The expansion is critical for continued economic advancement in one of the state's most dynamic and crosscutting technology strengths, which supports the competitiveness of other important North Carolina sectors such as advanced manufacturing, automotive, and aerospace.

OSTI's latest report—*North Carolina in the Next Tech Tsunami: Navigating the Data Economy (2017)*—clearly demonstrates the critical need for increased data science education programs. The report recommends comprehensive data training at every level of education in North Carolina. The mismatch between the tremendous demand for data skills and the supply from North Carolina universities and colleges has hampered the state's economic progress.

According to the McKinsey Global Institute, "by 2018, the U.S. will face a shortage of 190,000 workers with deep analytical skills and 1.5 million managers with the analytics know-how to drive decisions." In our in-depth survey of North Carolina employers, a shortage of applicants and lack of adequate training in candidates were two of the top three challenges identified as barriers to hiring data professionals. Data companies such as IBM, SAS and Red Hat, bioscience companies such as Quintiles and PPD, and financial and energy companies in Charlotte, are enormous consumers of data science graduates. UNC-Chapel Hill's intention to focus on data science technologies and to explore partnerships with North Carolina's military will be a much-needed addition to the data education portfolio in the state.

Please seriously consider UNC-Chapel Hill's request as a means of strengthening the state's present and future workforce. Do not hesitate to contact me for further discussion.

Sincerely,

John W. Hardin

North Carolina Department of Commerce | Office of Science, Technology & Innovation
301 North Wilmington Street | 1326 Mail Service Center | Raleigh, NC 27699-4300
919 814 4642 T

Dear Dr. Van Noort,

As Median Technologies Chief Operating Officer I am acutely aware of the value of and need for technically trained data professionals who understand business needs. Median Technologies, the industry leader in Imaging Phenomics™ , has spent the last twelve years partnering to advance the field of medical imaging and know that data is at the heart of what we do.

Median Technologies has current needs and will have additional needs in the future for new employees (entry level and mid-level) who understand not only the current tools of Data Science but the statistics, modeling and programming skills necessary to help Median Technologies be competitive in a big data world.

Median Technologies is pleased to be part of the proposed Data Science PSM at UNC Chapel Hill Industrial Advisory Board (IAB) and fully support the launch of the program. I believe the program and its graduates can help fill Median Technologies' needs and is necessary to meet the growth opportunity for North Carolina employers.

Please let me know if you have questions.

Sincerely,

J. HECHT

Jeanne Hecht, MBA, PMP
Chief Operating Officer

Median Technologies Inc.
Legal address: C/O Pramex International, 1251 Avenue of the Americas, 3rd Floor, New York NY 10020
US offices: 300 TradeCenter, Suite 5610, Woburn MA 01801
Tel +1 781 305 3363 Fax +1 781 281 7248
www.mediantechnologies.com

QuintilesIMS™

Dear Dr. Van Noort,

As the Head of Cognitive and Automation solutions in the R&D IT Solutions group for QuintilesIMS I am aware of the value and need for technically trained data science professionals who:

- Understand business needs;
- Are able to handle multiple disparate data sources;
- Can analyze data utilizing many different analytic methods;
- Can run the data and analytics on multiple different technical platforms.

QuintilesIMS continues to look for new employees (entry level and mid level) who understand these capabilities and can apply them to various QuintilesIMS business units to keep the company competitive in a big data world.

QuintilesIMS is pleased to be part of the proposed Data Science PSM at UNC Chapel Hill Industrial Advisory Board (IAB) and fully supports the launch of the program. I believe the program and its graduates can help fill QuintilesIMS's needs and is necessary to meet the growth opportunity for North Carolina employers.

Gary Shorter,

Head of Cognitive and Automation Solutions,

QuintilesIMS R&D Solutions.

UNC
COLLEGE OF
ARTS & SCIENCES

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

OFFICE OF THE DEAN
205 SOUTH BUILDING
CAMPUS BOX 3100
CHAPEL HILL, NC 27599-3100

T 919.962.1165
F 919.962.2408
college.unc.edu

September 21, 2017

Dr. Kim Van Noort
Vice President for Academic Programs and Instructional Strategy
University of North Carolina at Chapel Hill

Dear Dr. Van Noort:

As Senior Associate Dean for Natural Sciences in the College of Arts and Sciences at the University of North Carolina at Chapel Hill (UNC-Chapel Hill), I am writing to enthusiastically offer my continued support for the Data@Carolina initiative and their Request to Plan application for a Professional Science Master's (PSM) in Data Science program.

The proposed Data Science PSM aims to provide advanced training in data science for professionals with three or more years of work experience, as well as recent college graduates. The data science applications for this PSM will be drawn from specific scientific domains in which UNC-Chapel Hill has considerable expertise; these include environmental science, social science, public health, pharmacy, public policy, and city and regional planning. The proposed program is structured as a 12-month, full-time (30-credit) experience that begins with a 3-credit seven-day Data Science Essentials 'boot camp', a course designed to provide remediation coursework and team building. Students will then complete 15 credits of modular courses in core data science concepts, 4.5 credits of required elective data science courses, and 4.5 credits of professional skills courses. The program concludes with a 3-credit capstone team-based practicum under the mentorship of co-mentor teams drawn from UNC-Chapel Hill and a non-academic partner. The practicum includes the preparation of a final oral presentation and paper.

The proposed Data Science PSM aligns with the UNC System 2013-2018 Strategic Directions for Our Time, Our Future and the mission of UNC-Chapel Hill. Specifically, the proposed program is responsive to state needs and the needs of its citizens for a workforce equipped with advanced training in data science, including the social and ethical implications of data science applications. The program also will help UNC-Chapel Hill, the flagship of the UNC System, strengthen academic quality and fulfill its mission to instill data science education throughout the university system. Data@Carolina's established relationships with the Renaissance Computing Institute (RENCI), the National Consortium for Data Science (NCDS), and the NSF-funded South Big Data (BD) Hub present an enormous opportunity for Data Science PSM students to engage with industry

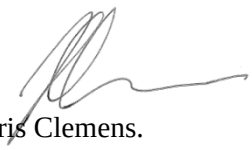
and other non-academic leaders and help solve real-world data challenges. Importantly, the proposed Data Science PSM program will build on existing resources (e.g., modular courses will be developed using existing courses) and adopt a sustainability plan that involves a tuition differential in order to maximize efficiencies and ensure financial stability.

The four submitting academic units (Department of Computer Science, Department of Mathematics, Department of Statistics and Operations Research, and School of Information and Library Science) are well suited to lead the proposed data science program. In addition to these units, the Data@Carolina initiative has generate widespread enthusiasm from across campus, including support from Carolina Health Informatics Program. Moreover, program leaders have received commitments from non-academic partners drawn from the industry, non-profit, government, and defense sectors. In addition, Data@Carolina's existing relationships with RENCI, the NCDS, and the South BD Hub will foster new commitments from non-academic organizations. This is significant as academic/non-academic partnerships are recognized as having the potential to produce far-reaching benefits for all stakeholders, especially in data- and technology-oriented fields such as data science.

I applaud the strong leadership provided by Dr. Kevin Jeffay and Dr. David Gotz, co-Chairs of the Data Science PSM Committee. I expect that the thriving Data@Carolina initiative will not only guide the establishment of a highly successful Data Science PSM program, but also foster other valuable educational opportunities at UNC-Chapel Hill, including a Data Science Certificate program.

I am excited to support the proposed Request to Plan application for the PSM in Data Science. Please do not hesitate to contact me with any questions you might have.

Regards,



Chris Clemens.
Senior Associate Dean for Natural Sciences
UNC College of Arts & Sciences
University of North Carolina at Chapel Hill

UNC
SCHOOL OF MEDICINE
DEPARTMENT OF PHARMACOLOGY

July 13, 2017

Dear Dr. Van Noort,

The Curriculum in Bioinformatics and Computational Biology (BCB) supports the addition of a Data Science PSM to the UNC Graduate School. The proposed Data Science PSM is highly synergistic with the BCB Curriculum, and we believe that it would lead to collaborative opportunities that are well aligned with BCB's core missions of research and teaching. The proposed program will help train a new generation of professionals with the data science skills that are in critical demand in today's data-driven economy.

In particular, the BCB curriculum looks forward to having Data Science PSM students specialize their training through coursework which teaches the foundations of the bioinformatics and computational biology domains. In addition, BCB research activities can serve as potential settings for the team-based capstone practicums required by the proposed Data Science PSM. Data science expertise is relevant to many of the research projects underway within BCB.

In summary, we support the addition of a Data Science PSM to the UNC Graduate School and we look forward to the collaborative opportunities that will emerge when the new PSM program is launched.

Sincerely,

Timothy Elston

Timothy C. Elston
Professor of Pharmacology
Director, Curriculum in Bioinformatics and Computational Biology

Department of Pharmacology • University of North Carolina
4009 Genetic Medicine Building, CB#7365, 120 Mason Farm Road, Chapel Hill, North Carolina 27599-7365
Phone (919) 966-1307 ● Fax (919) 966-5640