



THE
UNIVERSITY OF
NORTH CAROLINA
SYSTEM

Letter of Intent to Develop New Academic Degree Program

The following approvals must be obtained prior to sending the Letter of Intent to Develop a New Academic Degree Program to the UNC System Office.

Institution _____ University of North Carolina Charlotte _____

Degree Program Title (e.g. M.A. in Biology) _____ B.S. in Data Science _____

Reviewed and Approved By (Name and title only. No signature required in this section.)

Check box to indicate participation in review. (Provost is required.)

Provost: Joan F. Lorden

Faculty Senate Chair (as appropriate): n/a

Graduate Council (as appropriate): n/a

Undergraduate or Graduate Dean (as appropriate): John Smail, Associate Provost for Undergraduate Education & Dean of University College

Academic College Dean: Fatma Mili, Dean, College of Computing and Informatics, **Nancy Gutierrez**, Dean, College of Liberal Arts and Sciences

Department Chair: Bojan Cukic, Chair, Department of Computer Science, **Mary Lou Maher**, Chair, Department of Software and Information Systems

Program Director/Coordinator: Bojan Cukic, Interim Director, Data Science Initiative

New Academic Proposal Process

New academic programs are initiated and developed by the faculty members. Approval of the Letter of Intent to Develop a New Academic Degree Program must be obtained from department chairs and college deans or equivalent administrators before submission to the UNC System Office review.

Directions: Please provide a succinct, yet thorough response to each section. Obtain the Provost's signature and submit the proposal via the PREP system to the UNC System Vice President for Academic Programs, Faculty, and Research, for review and approval by the UNC System Office. Once the Letter of Intent to Develop is approved, the institution can begin work on the formal Request to Establish a New Degree Program.

Letter of Intent to Develop a New Academic Degree Program

Institution	University of North Carolina Charlotte
Joint Degree Program (Yes or No)? If so, list partner campus.	No
Degree Program Title (e.g. M.A. in Biology)	B.S. in Data Science
CIP Code and CIP Title (May be found at National Center for Education Statistics)	30.0801
Require UNC Teacher Licensure Specialty Area Code (Yes or No). If yes, list suggested UNC Specialty Area Code(s).	No
Proposed Delivery Mode (campus, online, or site-based distance education). Add maximum % online, if applicable.	Campus
Proposed Term to Enroll First Students (e.g. Spring 2019)	Fall 2019
List other programs in the UNC System (may be found at UNC System website)	None

SACSCOC Liaison Statement: *(Provide a brief statement from the University SACSCOC liaison regarding whether the new program is or is not a substantive change.)*

The BS in Data Science program is a significant departure in content from what is currently offered at the institution. Therefore, a substantive change prospectus must be submitted and approved by SACSCOC prior to implementation.

Program Summary: *(Briefly describe the proposed program and summarize the overall rationale.)*
Maximum of 1,000 words.

In May 2018 the National Academies of Sciences, Engineering, and Medicine (NAS) issued a report from the Committee on Envisioning the Data Science Discipline entitled “Data Science for Undergraduates: Opportunities

and Options.”¹ This report unequivocally recommends that universities develop undergraduate degrees in Data Science (Recommendation 2.1).

Data Science is a rapidly developing field. A number of universities have developed Master’s and doctoral degrees in Data Science within the last decade in order to respond to growing demand for ‘big data’ analytics. However, as the NAS report documents, the increase in automation, data engineering and analytics means that demand for undergraduate data science programs is growing. Graduates with bachelors’ degrees in Data Science will be equipped to “operate the systems on which analyses are run, prepare data for analysis, and visualize information.” More broadly, a Data Science undergraduate degree provides students with “data acumen,” a wide range of competencies including:

- Mathematical/Computational/Statistical Foundations,
- Data management, visualization, modeling and assessment,
- Workflow and reproducibility,
- Communication and teamwork,
- Domain specific considerations, and
- Ethical problem solving.

These competencies will prepare graduates for careers in a broad range of fields where the ability to understand and use data is critical.

The University of North Carolina Charlotte (UNC Charlotte) is proposing a new Bachelor of Science in Data Science degree that fully responds to the opportunities articulated in the NAS report. The University has already developed significant capacity in the field with an ongoing data science initiation and goal of the creation of a cross-college School of Data Science as well as the implementation of very successful Professional Science Masters’ programs in Health Informatics and Data Science and Business Analytics. However, well before the release of the NAS report, UNC Charlotte’s Data Science faculty, working with industry partners, realized that there was a need for an undergraduate degree in the field and began planning the state’s **first undergraduate degree** in the field.

The curriculum for UNC Charlotte’s proposed BS in Data Science is fully aligned with the recommendations in the NAS report. In particular, the report recommends that an undergraduate data science degree should be different from traditional computer science or statistics majors; it recommends that the degree be open to a broad range of students and equip them for success in a broad range of careers (Recommendations 2.2, 4.1). Responding to that charge, the curriculum for UNC Charlotte’s BS in Data Science will be built around a sequence of four 6-hour studios, one in each of the four years. These studio experiences will allow students to progressively develop mathematical skills, computational and statistical thinking, data modeling, and knowledge engineering in at least one application domain. The studio format for these core courses ensures that the development of technical competencies will be situated in the context of domain knowledge because each studio will focus on a real-world problem. In addition to technical competencies, students will develop teamwork, communication, and problem solving skills as well as building a deep understanding of the ethics and privacy issues (Recommendation 2.4). Complementing these data science studio experiences, the curriculum

¹ NAS Report: http://sites.nationalacademies.org/cstb/currentprojects/cstb_175246

will include a set of core course requirements in both computing and statistics. In addition, students will have the opportunity to further enhance their degree by pursuing richer domain knowledge and/or deeper technical skills. The 120-credit hour curriculum will include opportunities for experiential learning and will be offered in a classroom setting, where active learning methodologies will be used wherever appropriate.

UNC Charlotte's proposed BS in Data Science directly supports the mission of the University of North Carolina system, "to discover, create, transmit, and apply knowledge to address the needs of individuals and society." A critical component of data science education is to guide students to develop data acumen. This requires exposure to key concepts in data science, real-world data and problems that can reinforce the limitations of tools, and ethical considerations that permeate many applications. Key foundational concepts related to data acumen are at the core of competitive capabilities of every business, government, or non-profit organization today. The ability of UNC institutions to incorporate data science best practices is the key component in their long-term viability, resilience, and sustainability.

The proposed new degree program also addresses key elements in the mission of UNC Charlotte. As North Carolina's urban research university, UNC Charlotte leverages its location in the state's largest city to offer internationally competitive programs of research and creative activity, exemplary undergraduate, graduate, and professional programs, and a focused set of community engagement initiatives. UNC Charlotte's data science initiative brings together faculty from the Colleges of Computing and Informatics, Liberal Arts & Sciences, Business, and Health and Human Services. By exposing students to real-world data and problems, the undergraduate Data Science program will emphasize educational considerations that clearly align with UNC Charlotte's mission, including social mobility, public policy, and urban analytics. We have clear evidence from employers in the region of their interest in graduates who have the competencies we will be developing in this degree.

As noted, UNC Charlotte's proposed BS in Data Science is the first undergraduate degree in Data Science in North Carolina. Currently Fayetteville State, NC State, and UNC Charlotte offer post-baccalaureate certificates in Data Science. UNC Wilmington, East Carolina, Appalachian State, NC State and UNC Charlotte offer Master's degrees in the field. At UNC Charlotte, Professional Science Master's programs in Health Informatics and Data Science and Business Analytics narrowly focus on the two specialized application areas. Our graduate programs focus on offering working professionals practical knowledge and tools necessary to advance in current jobs or switch careers and thrive in specific sectors of data driven economy. The proposed undergraduate degree will prepare graduates for work in virtually every job sector and in a number of roles.² If other institutions within the UNC System seek to develop undergraduate degree programs in Data Science, UNC Charlotte will be open to share its experiences and insights.

Student Demand: *(Provide evidence of student demand. Discuss the extent to which students will be drawn from a pool of students not previously served by the institution. Maximum length 1,000 words.)*

Given that the discipline of Data Science is so new and that undergraduate degrees are, as yet, relatively rare, there is limited direct evidence on student demand. The NAS report published in May 2018 identified eight

² http://sites.nationalacademies.org/cstb/currentprojects/cstb_175246; pp. S-2

undergraduate degree programs in Data Science in the country including the University of Michigan, Virginia Tech, UC San Diego, UC Irvine, University of Rochester, MIT and New York University. This list is not exhaustive, but the caliber of the institutions offering degrees in the field is obvious and most of these programs are only a year or two old and enrollment figures are not publicly available.³ At the University of California at Berkeley, the new major in Data Science has been approved and will enroll students in Fall 2018. However, data science courses have been extremely popular with students from other majors on campus. In a recent conversation (July 2018), the Chair of the Department of Electrical Engineering and Computer Science at UC Berkeley Prof. James Demmel revealed that 1,470 undergraduate students have already registered for the introductory undergraduate “Data 8” course offered in Fall 2018.

Indirect evidence of student demand at UNC Charlotte and in North Carolina is also abundant. For example, student demand for enrollment in UNC Charlotte Master’s level programs should be a relevant metric. UNC Charlotte launched its Data Science and Business Analytics (DSBA) Professional Science Master’s degree in 2014. Despite being one of the first such degrees in the country, and with minimal marketing, the program receives over 700 applications a year, and it is enrolled to capacity with 175 students. Given the admissions requirements for a Master’s degree this level of student interest suggests that demand for an undergraduate degree will be significant too.

A second source of evidence for student demand is enrollment trends in related undergraduate fields such as applied mathematics and computer science. Between 2013 and 2017 undergraduate enrollment in applied mathematics (specifically the major in Mathematics for Business) has almost tripled from 42 to 117, and over the same period the number of majors in all fields of Computer Science at UNC Charlotte has almost doubled from 1071 to 1875. While the proposed BS in Data Science may recruit some of the students currently choosing these majors, its overall impact will be to complement rather than compete with these existing degree programs. The strong demand for these degrees suggests that the student demand for the proposed BS in Data Science will be robust, and this is particularly true given the excellent job placement prospects for graduates with these skills and the job satisfaction and salaries in the field.⁴

In this regard, it is important to stress that the curriculum of the proposed degree is specifically designed to have much broader appeal than more traditional computer science or applied mathematics degrees in two respects. First, the tightly structured sequence of pre-requisite courses in the current majors represents a barrier for transfer students or students who are changing their major. This is particularly true for computer science and as a result a relatively large number of students start in the major having already earned 45-60 hours but requiring six more semesters to graduate. (An unknown number of students simply do not declare the major because they cannot finish the required courses in a timely manner.) Based on both national evidence such as that presented in the NAS report on “Data Science for Undergraduates” and the expertise of the local and regional employers who are members of UNC Charlotte’s Data Science Initiative advisory board, we will design the BS in Data Science to be much more flexible.⁵ It will obviously have some prerequisite sequences, but the degree will be open to a much broader group of students including new transfers from community colleges that do not offer

³ http://sites.nationalacademies.org/cstb/currentprojects/cstb_175246; pp. 3-5 to 3-6

⁴ https://www.glassdoor.com/List/Best-Jobs-in-America-LST_KQ0,20.htm

⁵ http://sites.nationalacademies.org/cstb/currentprojects/cstb_175246; pp. 4-2 to 4-4

the full complement of computing or applied mathematics courses. Second, the real world, problem-solving focus will make the BS in Data Science attractive to students who do not see themselves as computing or mathematics majors. Students' perception that they are not a good 'fit' for a computer science or mathematics major is one of reasons why those fields, and STEM disciplines more generally, have problems attracting women and underrepresented minorities. Research in STEM education and Computer Science education specifically, suggests that a problem based curriculum similar to the one proposed for the BS in Data Science can make a crucial difference in attracting underrepresented students to the field.⁶ In both respects, then, UNC Charlotte's proposed degree will allow us to educate students not currently served by the institution in this field.

Societal Demand: *(Provide evidence of societal demand and employability of graduates from each of the following source types. Maximum length 1,000 words)*

There is abundant evidence of societal demand for the graduates of the proposed BS in Data Science. In a study released in 2017, the job market analytics firm Burning Glass partnered with IBM and the Business Higher Education Forum to study the emerging impact of Data Science in the job market.⁷ The results suggest a rapid transformation across almost all industry clusters (and government and non-profit as well) as firms and organizations respond to the realities of 'big data.' In 2016 alone, the number of jobs specifically advertised for data science grew by 54%, and there was a corresponding growth in the number of postings for positions requiring the kinds of skills that a data science undergraduate would possess including quantitative data analysis and data visualization. The report predicts that 364,000 new data science positions will be created by 2020. The report describes the job market in data science as extending over a spectrum of analytical rigor from individuals with doctoral degrees who create the sophisticated models to "data savvy" workers who will need a foundational understanding of data and analytics to work on teams with more technically focused members. In the latter category alone, the report anticipates more than 100,000 new job postings by 2020. Significantly, while the report shows that some areas of the data science job market require talent with advanced degrees, most do not. Overall, only 6% of the postings analyzed required a graduate degree. Finally, this report makes clear that because of the paucity of graduates with specific qualifications in the field, positions take longer than average to fill and employers are casting widely for individuals with the requisite skill set.

To complement the national picture provided by the Burning Glass / IBM / BHEF report, UNC Charlotte commissioned a report from EAB on the job market for undergraduate data science graduates in North Carolina and the findings are similar.⁸ Between the second half of 2013 and the first half of 2017, the number of positions posted in North Carolina that specifically required a bachelors' in Data Science grew by 76%, and in the Charlotte region the growth was 109%. More broadly, positions that mention competencies developed in a BS in Data Science grew from 2,337 to 4,777 in the last year. Similar information is conveyed in the IT Job Trends reports gathered by NC Tech Association.⁹ As is true nationally, firms and organizations are seeking to hire

⁶ http://sites.nationalacademies.org/cstb/currentprojects/cstb_175246; pp. 4-2 to 4-4

⁷ "The Quant Crunch: How Demand for Data Science Skills is Disrupting the Job Market," Burning Glass Technologies, 2017, available for download at <https://www.burning-glass.com/research-project/quant-crunch-data-science-job-market/>

⁸ "Employer Demand for Bachelor's - Level Data Science Professionals, custom report for UNC Charlotte prepared by EAB; full report included in the appendix.

⁹ https://www.nctech.org/_files/_pdf/Tech%20Talent/NC%20Tech%20Trends-May%202018.pdf

across the spectrum of data science. Importantly, there is strong employment potential for individuals with the type of broad, applied expertise that UNC Charlotte's BS in Data Science will be designed to develop. The report notes the small numbers of undergraduate data science degrees being offered nationally and only identified one possible North Carolina program -- a "possible Undergraduate minor in Data Science/Data Studies" at the University of North Carolina Chapel Hill.¹⁰

Finally, as part of the degree planning process, UNC Charlotte consulted with employers in the region to assess their needs for graduates with data science skills and their assessment of the employability of students completing the proposed BS in Data Science. Executives from 10 companies quickly replied and expressed undivided support for the creation of the program (see attached). The companies they represent include the range from small analytic consultancy start-ups (Hague Advisory) to well established data analytics providers (Quaero, ADP Ventures, Grant Thornton, Gray Matter Analytics), large corporations (Bank of America, Wells Fargo, TIAA, Duke Energy) and product developers (MapR Data Technologies). All the letters quote national and regional statistics about current and anticipated labor shortage in data analytics and strongly endorse the proposed undergraduate Data Science degree program at UNC Charlotte. Mr. Tim Reagan of Gray Matter Analytics offered a testimony that his previous employer "had to leverage Executive Search firms to acquire entry to mid-level talent", a very expensive approach to solve staffing shortage in the data science domain. He explicitly encourages the creation of the BS in Data Science as "the great response to a growing market need". Joel Amick of TIAA also strongly supports the new degree program because "... finding the right people who are capable of working in cross-functional teams, incorporating domains like statistics, engineering, and business analysis, requires a different type of preparation." Tom Fisher of MapR Technologies emphasizes that "today's market allows knowledge workers to live and work anywhere", allowing his company headquartered in Silicon Valley to hire UNC Charlotte's graduates who may want to stay in this area. Chris Heck of Duke Energy notes that the keys to digital transformation of his company include the knowledge and skills of future Data Science program graduates. Misha Dosh of ADP Ventures – Big Data emphasizes that "...it is imperative that we feed the pipeline of qualified candidates interested in the data sciences" calling the proposed program "a proactive investment in the field of professional data sciences; a field that will continue to grow well into the future."

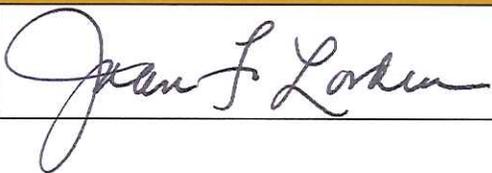
In summary, industry support letters representing a large cross-section of companies in the region, demonstrate the interest for data science talent in general and strongly support the initiative to create BS Data Science degree at UNC Charlotte. Their letters do not appear to leave any doubt about the employment prospects of our future students.

¹⁰ <https://research.ncsu.edu/dsi/education/education-unc-ch/>

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

Position Title	Name	E-mail Address	Telephone
Dean of the College of Computing and Informatics	Dr. Fatma Mili	fatma.mili@uncc.edu	704-687-8450
Dean of the College of Liberal Arts and Sciences	Dr. Nancy A. Gutierrez	ngutierr@uncc.edu	704-687-0081
Chair of the Department of Computer Science, and Interim Director of the Data Science Initiative	Dr. Bojan Cukic	bcukic@uncc.edu	704-687-6155
Chair of the Department of Software and Information Systems	Dr. Mary Lou Maher	M.Maher@uncc.edu	704-687-1940

This Letter of Intent to Plan a New Program has been reviewed and approved by the appropriate campus authorities.

Position Title	Signature	Date
Provost		8/24/2018



June 14, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Mr. Hertel:

I am writing to express my strong support for UNC Charlotte's proposed new degree program in Data Science (Bachelor of Science). I am Head of the Advanced Techniques for Modeling Group in Corporate Model Risk (CMoR) and a senior member of the Quantitative Modeling community in Wells Fargo. Data Science has become increasingly important in banking and financial institutions, and much of our current work deals with modeling, computing, and visualization. More recently, we are moving to machine learning and AI with application covering credit, operational, and market risk, anomaly detection, natural language processing for chatbots, document automation, and various kinds of text analytics.

Before joining Wells Fargo, I was in academia for a long time. I was the Donald A. Darling professor of statistics at the University of Michigan, Ann Arbor and I also served as Chair of the Statistics Department for 12 years. During my time there, I was instrumental in launching multiple initiatives on Data Science. I led the efforts to start an undergraduate degree program in Data Science in 2015. This was a joint program between the College of Literature, Science & Arts and the College of Engineering. Our market analysis indicated a huge need for Data Scientists at all levels and the country was facing a shortfall of several hundred thousand jobs over the next 10 or so years. More recently, UM has started a Master's program in DS. Many other major universities across the country have also been launching similar programs to educate students in this emerging area of study, one that is turning out to be critical importance. In addition, many academic institutions have also started initiatives to promote cross-campus research collaborations and stimulate partnerships with industry. At UM Ann Arbor, I was instrumental in creating the Michigan Institute for Data Science (MIDAS) which had an initial funding of \$100M by the University. MIDAS has become very successful and has been serving as an incubator for transformative applied research in key areas, including Intelligent Transportation, Personalized Medicine, Social Sciences and Learning Analytics. It brings together students and faculty across campus to share their interests in, and learn about, data-intensive research.

In summary, I am very excited to see the proposed degree program in Data Science and UNCC. Graduates with these skills are in short supply, both in industry and the research community, so we are pleased to endorse this program enthusiastically.

Sincerely

Vijay Nair, PhD
Managing Director and Head of Advanced Technologies for Modeling
Corporate Model Risk (CMoR)



June 6, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends,

I am writing to express my strong support, on behalf of Hague Advisor Services for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

I have led and hired hundreds of analytics professionals over the last 20 years in financial services, telecom and aerospace companies and am now advising large companies across many more industries about how to build analytical capabilities including data science teams. In all of this, talent is a common factor of concern and stress for the executives leading the programs. As I've hired for the teams and advised others, any company needs to have a range of skills capability. In a universities terms, this is thought of as bachelors, masters and PhD program. UNC Charlotte has a masters program in data science and business analytics, but no undergraduate program. This is a large gap. For many years, I've hired, mathematicians, computer scientist, engineers, and economist at the BS level and then had to take their raw talent and train them in data science and analytics. It was always the students who had one of the degrees with computer science as a minor or second major that were the closest to what we were looking for. The demand for these skills set continue to expand and will for years to come.

I see the proposed creation of the new undergraduate degree in Data Science as great response to market demand. For this reason, I believe every institution of higher learning should be investing in data science educational opportunities for its students - and none more so than UNC Charlotte.

Sincerely,

Douglas C. Hague PhD
Chief Analytics Officer-Hague Advisory Services
Chair-Industrial Advisory Board, UNCC Data Science and Business Analytics Program

June 9, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends,

I am writing to express my strong support, on behalf GrayMatter Analytics for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

I have led and developed multiple organizations in the Healthcare analytics space, specifically in the last 10 years. During this time, as the analytics discipline has matured, there continues to remain deficit of qualified resources in the market place to meet the current demand for talent. While at Carolinas Healthcare, our analytics department had to leverage Executive Search firms to acquire entry to mid-level talent. This was an expensive approach to solve the war on talent, specifically in the Charlotte market.

This demand for talent will continue to grow across all business verticals, including healthcare. Understanding this opportunity, in my perspective, positions UNCC to provide a curriculum for current and future students to meet this growing demand for talent. The creation of the new undergraduate degree in Data Science is a tremendous opportunity for UNCC, the City of Charlotte, and the Charlotte Business community.

Sincerely

Tim Reagan
Vice President, Gray Matter Analytics

June 15, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends,

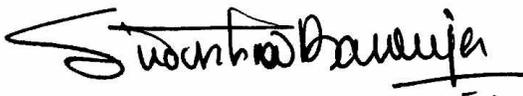
I am writing to express my strong support for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

I have spent a large part of my career working on advanced analytics related roles. During this time, I have experienced rapid transformations in the way data is increasingly being viewed as an asset and is leveraged in driving strategic decisions. Areas of rapid growth include not only modeling data through Artificial Intelligence, Machine Learning, Deep Learning etc. but also capturing and wrangling structured, unstructured and semi structured data and storyboarding the outcome. Advanced analytics therefore encompasses a wider range of skills starting from sourcing the data all the way through cataloging, curating, communicating and executing the data driven outcomes. This type of skillset usually resides in the intersection of data, technology and business and is a critical need today. A degree in Data Science provides a nice integration point between data, technology and business application.

The demand for these skills continue to expand and will for years to come. Therefore, a requirement for an interdisciplinary area of study is a proactive response to the growing demand. UNC Charlotte already has a Master's Program in Data Science and Business Analytics but not an undergraduate degree. This is a large gap. The proposed Bachelor of Science degree will ensure that we have a qualified candidate pool equipped with the right skills, knowledge and expertise to be successful in the Master's Program and fill the talent gap.

I see the proposed creation of the Bachelor of Science in Data Science degree as great response to a growing market demand. It will catalyze building data science leaders of the future.

Sincerely,



Sudeshna Banerjee
Senior Vice President, Data Science Executive
Bank of America



Joel Amick
Director, Cyber Analytics and Data
Science
Cyber Security
T 704-988-3267
jamick@tiaa.org

June 8th 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends and Colleagues,

I am writing to express my strong support, on behalf of TIAA for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

In running a Data Science centric team I have seen firsthand how transformative a discipline like Data Science is to our future growth. As such, the need for qualified individuals to build out this workforce is critical and at an all-time high. As this space evolved so rapidly, we are hard pressed to keep up. In our company we are witnessing the rapid transformation of our work and our organizations with the rise of data science and a demand across every business domain. Areas of growth and innovation include, but are not limited to: machine learning, artificial intelligence, Image recognition and new methods for securing, managing, and mining massive flows of unstructured data. Each of these technologies is forcing us to completely re-think how we add value for our customers, how we staff our teams and how we plan and invest for the future.

New data-based technologies are also causing us to re-think the skills, experience, competencies, and the talents that will be required for successful professionals. Finding the right people who are capable of working in cross-functional teams, incorporating domains like statistics, engineering, and business analysis, requires a different type of preparation. Our company has a current need for professionals who possess a deep understanding of data science, and how to apply data tools and technologies to the most complex problems.

We see the proposed creation of the new undergraduate degree in Data Science as an agile response to market demand. The demand for new talent is not going to change - it will only intensify. For this reason, I believe every institution of higher learning should be investing in data science educational opportunities for its students - and none more so than UNC Charlotte as a critical generator of talent for a thriving and growing modern city like Charlotte. I have worked with UNCC on their Graduate program but the need for an undergrad in this discipline is paramount.

Sincerely

Joel Amick
Director, Cyber Analytics and Data Science
Advisory Board Member, UNCC Data Science Initiative



June 8, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends of UNC Charlotte,

I recently learned that the University has proposed a degreed program for a Bachelor of Science in Data Science. I wanted to take a moment as a thought leader in this industry and as an Executive in one of the largest providers of technology in the market.

As an industry thought leader residing in Silicon Valley and published author, most recently in Forbes, the prospect of UNC Charlotte offering a specific undergraduate program in Data Science is of tremendous interest and has my, personal, and my companies full support.

The single largest challenge in the market, today, has less to do with the technologies and more to do with the capabilities of the resources in the market today. Today's market allows knowledge workers to live and work anywhere which could be a secondary benefit of UNC Charlotte graduates who may want to stay in the area. The beauty of a program like this is that it will offer graduates an opportunity to move into any number of different vertical businesses because they have a solid foundation through an undergraduate degree in Data Science. A graduate of the proposed program could work in any vertical – from healthcare to financial services to retail to government. Our customers are demanding general purpose resources as the specific knowledge required to support their businesses can be more easily provided by their own industry subject matter experts (SMEs). What the program offers is an incredible opportunity for students to enter the job field with skills that will be applicable today and long into the future.

Artificial Intelligence, Machine Learning, Deep Learning technologies are all built and assume extensive knowledge in Data Science. In order to be effective in utilizing these emerging technologies employees must understand data – where it comes from, how it's represented, if it's structure, unstructured or semi-structured, if it's persisted in files, tables or streams. These are all fundamental to the success in leveraging and gaining business advantage from these emerging and rapidly growing technologies – all anchored around data science.

I personally see this new undergraduate degree in Data Science at UNC Charlotte as a demonstration of forward thinking and tremendous labor market understanding. I fully support UNC Charlotte focusing their previous investments in this specific educational area.

Thank you,

A handwritten signature in black ink, appearing to read "Tom Fisher".

Tom Fisher
Chief Technology Officer (CTO) and Executive Vice President, MapR Data Technologies
Member, Board of Directors at Rambus



J. Michael McGuire
Chief Executive Officer

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twitter.com/grantthorntonus

June 1, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends,

I am writing to express my strong support, on behalf of all my colleagues at Grant Thornton and across the accounting and consulting profession, for UNCC's proposed addition of two new degree programs in data science.

In our firm and our profession, we are experiencing what every organization and industry is experiencing: the rapid transformation of our work and our organizations from the accelerating rise of new data-based technologies. These include, but are not limited to: artificial intelligence, robotics process automation, data analytics and blockchain. Each of these technologies is forcing us to completely re-think how we do our work for our clients, how we staff our teams and how we plan and invest for the future.

New data-based technologies are also causing us to re-think the skills, experience, knowledge and talents that will be required for successful professionals in accounting and consulting in the future. Clearly, the requirements for this work in the 21st century will not be the same as they were in the 20th century. Professionals who possess a deep understanding of data science, and how to apply data tools and technologies to the most complex and stubborn challenges our clients face in running their organizations, will be central to the growth and progress of our profession going forward.

To put the matter simply: Data science and data-based technologies are re-creating our world, across every industry and every field of human endeavor. That trend is not going to change – it will only intensify. For this reason, I believe every institution of higher learning should be investing in data science educational opportunities for its students – and none more so than UNCC, the flagship public university for a thriving and growing modern city like Charlotte.

Thank you for pursuing this important initiative, and please do hesitate to reach out to me if I can be of further assistance.

Sincerely,

J. Michael McGuire
CEO



Chris Heck
VP and CIO
550 S Tryon Street
DEC20A
Charlotte, NC 28202

June 7, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Joshua,

On behalf of Duke Energy I would like to express my support for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

Duke Energy is on an accelerating path for digital transformation. We are looking across all our customer impacting and operational areas for 10x improvement opportunities. Keys to our digital transformation include data governance, data access, advanced analytics, artificial intelligence, and machine learning. These skills and technologies are foundational for our innovation and transformation.

We see the availability of resources with skills in these areas as a major concern. Finding new talent and upskilling our current workforce are prerequisites our transformation .

I know that many other businesses are on the same path. We are all looking to be more digital – and digital is fueled by the data sciences.

I expect the proposed degree program in Data Science will be in high demand throughout the region and I thank you for your foresight in addressing that demand.

Sincerely,

A handwritten signature in black ink, appearing to read "Chris Heck", written in a cursive style with a long horizontal flourish extending to the right.

Chris Heck

June 14th, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Friends,

I am writing to express my strong support for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

I have had the privilege of working in data science throughout my career that, thus far, spans 27 years and many of the world's most recognized brands. During that time, I have witnessed firsthand the evolving role that data has played in the decision-making practices of organizations of all sizes. Likewise, the roles and responsibilities of professionals with the skills, capabilities and education to enable businesses to achieve the maximum amount of benefit from their data and data science initiatives has evolved in tandem.

It is imperative that we feed the pipeline of qualified candidates interested in careers in the data sciences. UNC Charlotte's has a masters program in data science and business analytics, but no undergraduate program. We must begin to nurture data science professionals during their bachelors studies to ensure that they are equipped with the tools and education and success to position them for success in a masters program and beyond.

An undergraduate degree in Data Science is a proactive investment in the future of the field of professional data sciences; a field that will continue to grow well into the future. The program will benefit its participants, the university and organizations who rely on these professionals and their skills to drive their businesses. I believe that an initiative like this will develop the types of professionals that this growing industry needs with the competencies that it demands.

Sincerely,



Misha Ghosh
Division Vice President and General Manager
ADP Ventures – Big Data



June 11, 2018

Mr. Joshua Hertel
Director, Data Science Initiative
UNC Charlotte
9201 University City Boulevard
Charlotte, NC 28223

Dear Joshua,

I am writing to express my strong support, on behalf of Quaero, for UNC Charlotte's proposed degree program, the Bachelor of Science in Data Science.

Quaero is a customer data and analytics platform (CDP), based in Charlotte. We work with large companies in multiple vertical industries, including media, business to business services, retail and financial services. Quaero's CDP helps these companies harness their customer data to create insights that generate value for them and their customers.

The primary users of our platform within our clients are data engineers, data scientists and analysts. We have seen an explosion in the need for such talent at all levels, both within our company and at our clients. The demand for these skills set continue to expand and will do so for years to come.

We see the proposed creation of the new undergraduate degree in Data Science as an appropriate and timely response to market demand. For this reason, I believe every institution of higher learning should be investing in data science educational opportunities for its students. This is particularly true of UNC Charlotte, given Charlotte's growth and the critical need for this type of talent to sustain that growth.

Sincerely,

Naras Eechambadi

Naras Eechambadi, Ph.D.
Chief Executive Officer



DATA SNAPSHOT

Employer Demand for Bachelor's-Level **Data Science** Professionals

Analysis of Employer Demand and Comparable
Programming

COE Forum

Jacquelyn Katuin
Market Research Associate

Tess Wallenstein
Market Research Manager

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1) Research Methodology

Project Challenge Leadership at the University of North Carolina-Charlotte approached the Forum as they considered launching a bachelor’s-level data science program. Through a combination of quantitative data analytics and secondary research, the Forum sought to assess employer demand for bachelor’s-level data science professionals and the competitive landscape for a bachelor’s-level data science program.

EAB’s market research function provides insights which guide strategic programmatic decisions at member institutions. The Forum combines qualitative and quantitative data to help administrators identify opportunities for new program development, assess job market trends, and align curriculum with employer and student demand.

EAB reports rely primarily on labor market data from the Burning Glass Labor/Insight™ tool (description below). Reports occasionally use data from the United States Census Bureau and United States Bureau of Labor Statistics data to explore occupation and job trends. Market research reports may also incorporate Integrated Postsecondary Education Data System (IPEDS) data to assess student enrollment, demographics, and completion rates across competitor programs.

Methodology and Definitions **Methodology:** Unless stated otherwise, this report includes data from online job postings from September 2016 to August 2017. The Forum identified trends in employer demand over time, common job titles, in-demand skills, and employers with high demand for bachelor’s-level data science professionals.

Definitions: “State data” and “state” refer to North Carolina. “Local data” and “local” refer to the Charlotte-Concord-Gastonia, NC-SC Metropolitan Statistical Area (MSA).

Annual growth in job postings is measured in the change between July 2013 and June 2017 by six-month halves (i.e., H2 2013 is July 2013 to December 2013).

Burning Glass Labor/Insight™ **EAB’s Partner for Real-Time Labor Market Data**
This report includes data made available through EAB’s partnership with Burning Glass Technologies, a Boston-based leader in human capital data analytics. Burning Glass Technologies specializes in the use of web spidering technology to mine more than 80 million online job postings and analyze real-time employer demand. Under this partnership, EAB may use Burning Glass’s proprietary Labor/Insight™ tool to answer member questions about employer demand for educational requirements, job titles, and competencies over time, as well as by geography. The tool considers job postings “unspecified” for a skill, industry, employer, geography, certification, or educational requirement when the job posting did not advertise for one of these particular job characteristics. Unspecified postings represent null values and should be excluded from the total number (n value) of job postings analyzed in the query. A more complete description of the tool is available at <http://www.burning-glass.com/products/laborinsight-market-analysis/>.

For more information about the Labor/Insight™ tool, please contact Betsy Denious, Director of Business Development Learning & Policy at bdenious@burning-glass.com or 301-525-6596.

Project Sources

The Forum consulted the following sources for this report:

- EAB’s internal and online research libraries (eab.com)
- National Center for Education Statistics (NCES) (<http://nces.ed.gov/>)
- Profiled program webpages:
 - Bellevue College, Bachelor of Applied Science in Data Analytics, accessed October 2017, <https://www.bellevuecollege.edu/programs/degrees/bachelor/da/>
 - Columbia University, Bachelor of Arts in Data Science, accessed October 2017, <https://mice.cs.columbia.edu/c/d.php?d=228>
 - Southern New Hampshire University, Bachelor of Science in Data Analytics, accessed October 2017, <https://www.snhu.edu/online-degrees/bachelors/bs-in-data-analytics>
 - University of Michigan, Undergraduate Program in Data Science, accessed October 2017, <https://www.eecs.umich.edu/eecs/undergraduate/data-science/>
 - Utah Valley University, Applied Data Analytics Minor, accessed October 2017, <https://www.uvu.edu/catalog/current/departments/information-systems-and-technology/applied-data-analytics-minor/>
 - Western Michigan University, Bachelor of Science in Data Science, accessed October 2017, <https://wmich.edu/cs/academics/undergraduate/bs-data-science>

Profiled Institutions

The Forum prioritized profiles of institutions selected by administrators at the **University of North Carolina-Charlotte** (e.g., **Columbia University**). The Forum profiled programs via secondary research at the following institutions:

A Guide to Institutions Profiled in this Brief¹

Institution	Location	Approximate Institutional Enrollment (Undergraduate/Total)	Carnegie Classification
Bellevue College	Pacific West	13,500 / 13,500	Baccalaureate/Associate's Colleges: Associate's Dominant
Columbia University	Northeast	8,000 / 29,500	Doctoral Universities: Highest Research Activity
Southern New Hampshire University	Northeast	54,000 / 73,000	Master's Colleges & Universities: Larger Programs
University of Michigan	Midwest	29,000 / 44,500	Doctoral Universities: Highest Research Activity
Utah Valley University	Mountain West	34,500 / 35,000	Master's Colleges & Universities: Small Programs
Western Michigan University	Midwest	18,500 / 23,000	Doctoral Universities: Higher Research Activity

1) National Center for Education Statistics.

2) Executive Overview

Growing state and local demand for bachelor's-level data science professionals indicates an opportunity for the *University of North Carolina-Charlotte* to launch a program. Demand for bachelor's-level data science professionals in North Carolina rose 76 percent between H2 2013 and H1 2017 (i.e., 1,400 to 2,461 postings). In the same time frame, local employer demand for bachelor's-level data science professionals grew 109 percent (i.e., 590 to 1,236 postings). State and local employers seek bachelor's-level data science professionals in 4,777 and 2,337 job postings in the last year, respectively.

Limited competition further indicates an opportunity to develop a bachelor's-level data science program. Few institutions nationwide offer full bachelor's-level data science programs. National completions for programs related to data science and analytics grew seven percent between 2006 and 2015 (i.e., 48,240 to 51,559 completions), indicating growing student interest in data analytics. Administrators should note institutions of interest (e.g., **University of California-Berkeley, University of North Carolina-Chapel Hill**) plan to launch bachelor's-level data science programming in the coming years.

Integrate statistics, computer science, and business administration coursework in the bachelor's-level data science program to meet employer demand. Employers at the state and local levels often seek bachelor's-level data science professionals with business administration skills including 'project management' and 'budgeting.' As expected, state and local employers frequently express demand for data science professionals with data management skills such as 'data analysis,' 'SQL,' and 'data management.' Bachelor's-level data science programs frequently represent a partnership between two colleges such as a college of engineering and college of arts and sciences due to the emerging and interdisciplinary nature of the data science field.

3) Employer Demand Trends

Demand over Time

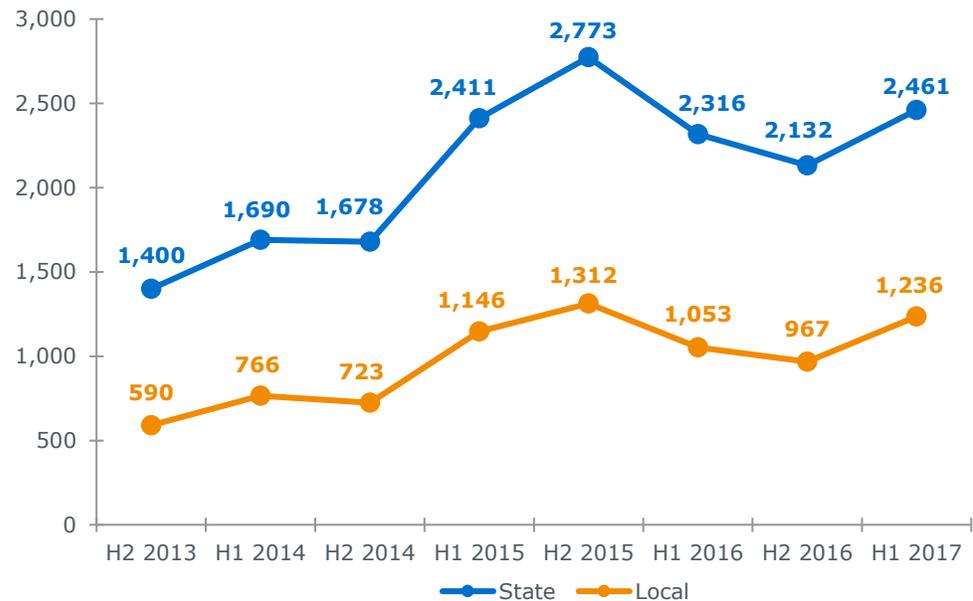
Launch a Bachelor’s-Level Data Science Program to Meet Growing State and Local Employer Demand

Growing state and local demand for bachelor’s-level data science professionals indicates an opportunity for the **University at North Carolina-Charlotte** to develop a bachelor’s-level data science program. Local demand for bachelor’s-level data science professionals rose 109 percent between H2 2013 and H1 2017 (i.e., 590 to 1,236 postings). A 122 percent increase in local demand for bachelor’s-level data science professionals occurred between H2 2013 and H2 2015 (i.e., 590 to 1,312 postings). After local demand peaked in H2 2015, demand decreased to 967 job postings in H2 2016 (i.e., a 26 percent decline). Most recently, demand for bachelor’s-level data science professionals rose 28 percent between H2 2016 and H1 2017 (i.e., 967 to 1,236 postings).

Across North Carolina, demand for bachelor’s-level data science professionals increased 76 percent between H2 2013 and H1 2017 (i.e., 1,400 to 2,461 postings). In H2 2013, North Carolina employers posted 1,400 relevant job opportunities, followed by a 65 percent increase in demand between H2 2014 and H2 2015 (i.e., 1,678 to 2,773 postings). Between H2 2015 and H2 2016, employer demand for bachelor’s-level data science professionals dropped 23 percent (i.e., 2,773 to 2,132 postings). Most recently, North Carolina employer demand increased 15 percent between the second half of 2016 and the first half of 2017 (i.e., 2,132 to 2,461 postings).

Historical Demand for Bachelor’s-Level Data Science Professionals

June 2013-July 2017, State and Local Data²



2) Burning Glass Labor/Insight™

In-Demand Skills

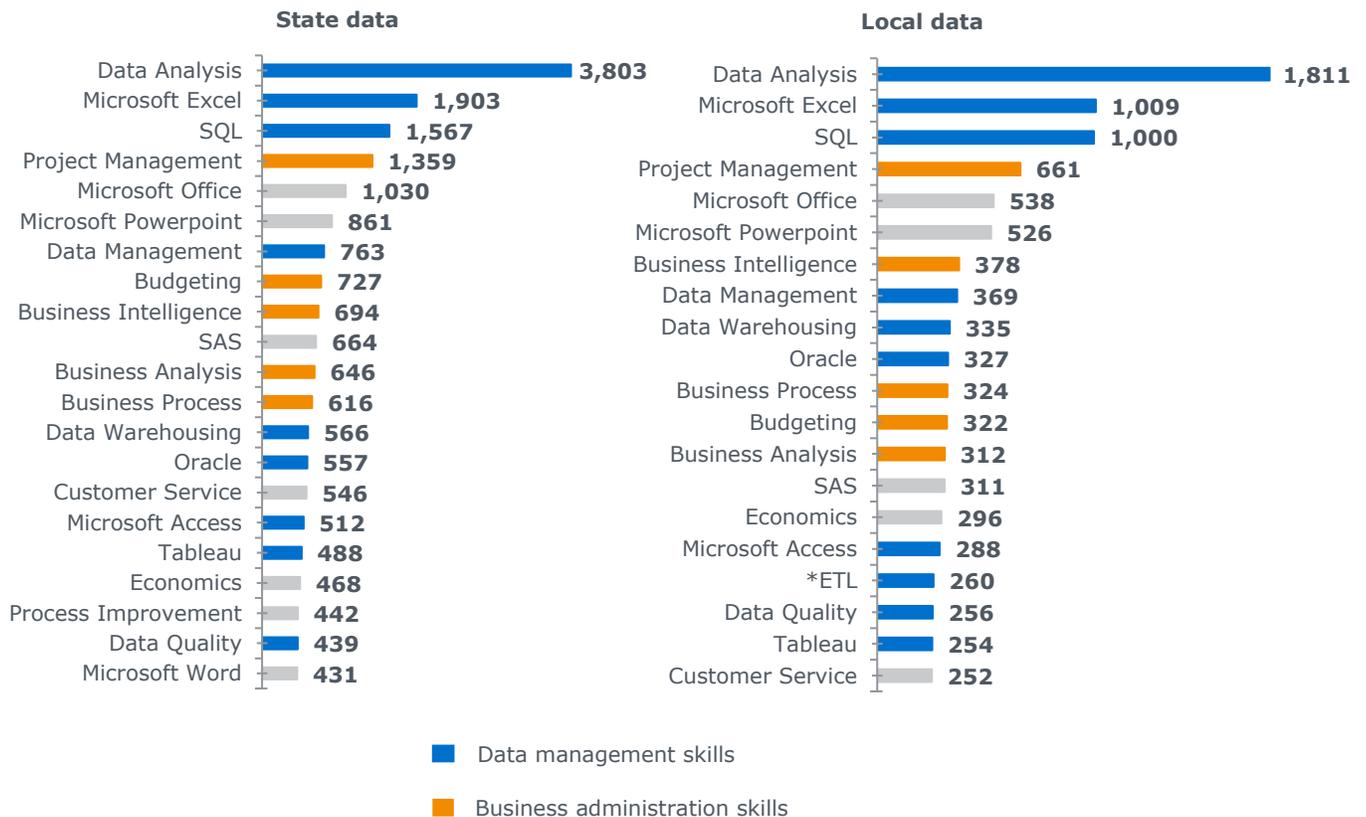
Confer Business Administration and Data Management Skills to Meet Employer Demand

State and local employers seek bachelor’s-level data science professionals with business administration skills such as ‘project management,’ ‘business intelligence,’ and ‘budgeting.’ As expected, state and local employers also seek bachelor’s-level data science professionals with data management skills such as ‘data analysis,’ ‘data warehousing,’ and ‘data quality.’ Program graduates should also possess knowledge of ‘Microsoft Excel,’ ‘SQL,’ and ‘Tableau’ to prepare for employment. For example, state and local employers seek bachelor’s-level data science professionals with knowledge of ‘SQL’ in 1,567 and 1,000 job postings, respectively. **Bellevue University** offers a course titled “SQL Fundamentals” to confer in-demand ‘SQL’ skills to bachelor’s-level data analytics students.

Commonly Requested Skills for Bachelor’s-Level Data Science Professionals

September 2016-August 2017, State and Local Data³

n (state)= 4,777 job postings, 0 unspecified postings; n (local)= 2,337 job postings, 0 unspecified postings



*Extraction Transformation and Loading (ETL)

3) Burning Glass Labor/Insight™

Commonly Posted Titles

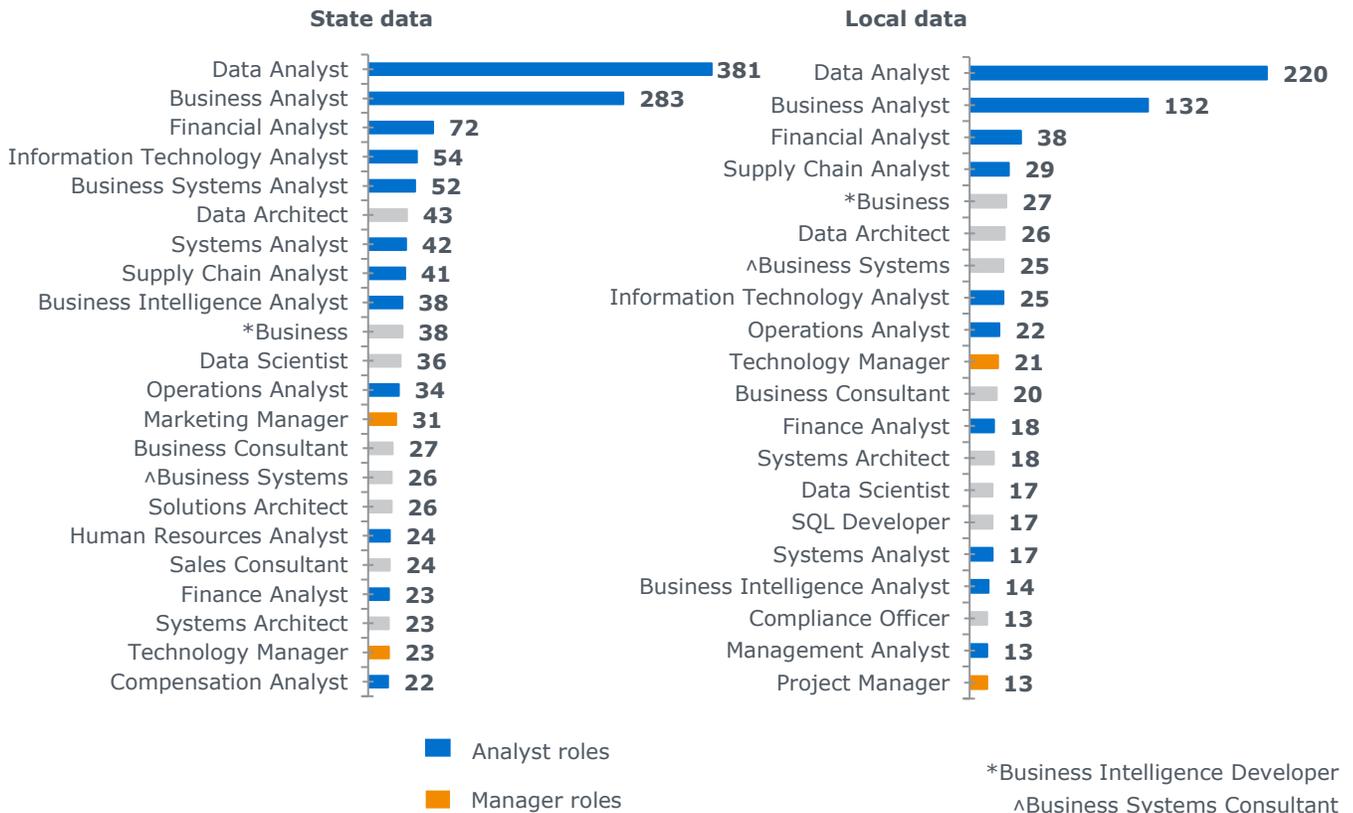
State and Local Employers Often Seek Bachelor's-Level Data Science Professionals for Analyst Roles

Employers across North Carolina and in the Charlotte metropolitan area express demand for bachelor's-level data science professionals to fill analyst roles and a limited number of manager roles. State and local employers seek bachelor's-level data science professionals for 'data analyst' roles in eight and nine percent of relevant job postings, respectively (i.e., 381 and 220 postings, respectively). Local employers also express demand for bachelor's-level data science professionals to fill 'business analyst,' 'financial analyst,' and 'supply chain analyst' roles. In addition to analyst roles, employers seek bachelor's-level data science professionals for a limited number of manager roles such as 'marketing manager,' 'project manager,' and 'technology manager.'

Frequently Posted Titles for Bachelor's-Level Data Science Professionals

September 2016-August 2017, State and Local Data⁴

n (state)= 4,777 job postings, 2 unspecified postings; n (local)= 2,337 job postings, 2 unspecified postings



4) Burning Glass Labor/Insight™

Employers with High Demand

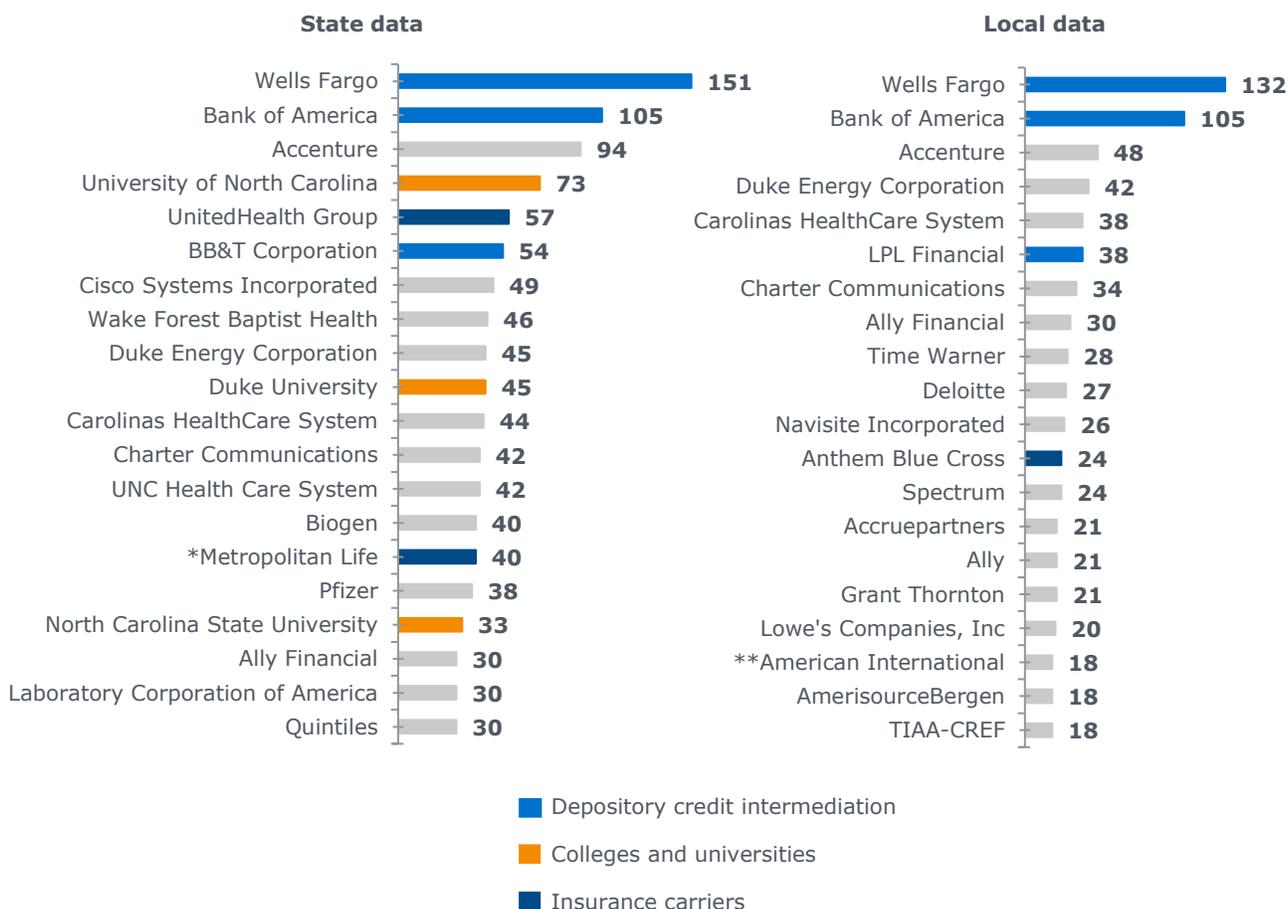
Encourage Students to Seek Employment in the 'Depository Credit Intermediation' Industry

'Depository credit intermediation' companies rank among the top employers with demand for bachelor's-level data science professionals (i.e., nine and 14 percent of relevant state and local postings, respectively). For example, Wells Fargo seeks bachelor's-level data science professionals in 151 and 132 postings at the state and local levels (i.e., three and six percent of relevant postings, respectively). Program graduates may also find employment at higher education institutions. Colleges and universities in North Carolina express demand for bachelor's-level data science professionals in 203 relevant postings (i.e., four percent of relevant postings). For example, the University of North Carolina and Duke University seek bachelor's-level data science professionals in 73 and 45 postings in the last year, respectively.

Employers that Seek Bachelor's-Level Data Science Professionals

September 2016-August 2017, State and Local Data⁵

n (state)= 4,777 job postings, 1,215 unspecified postings; n (local)= 2,337 job postings, 776 unspecified postings



*Metropolitan Life Insurance Company
 **American International Group Incorporated

5) Burning Glass Labor/Insight™

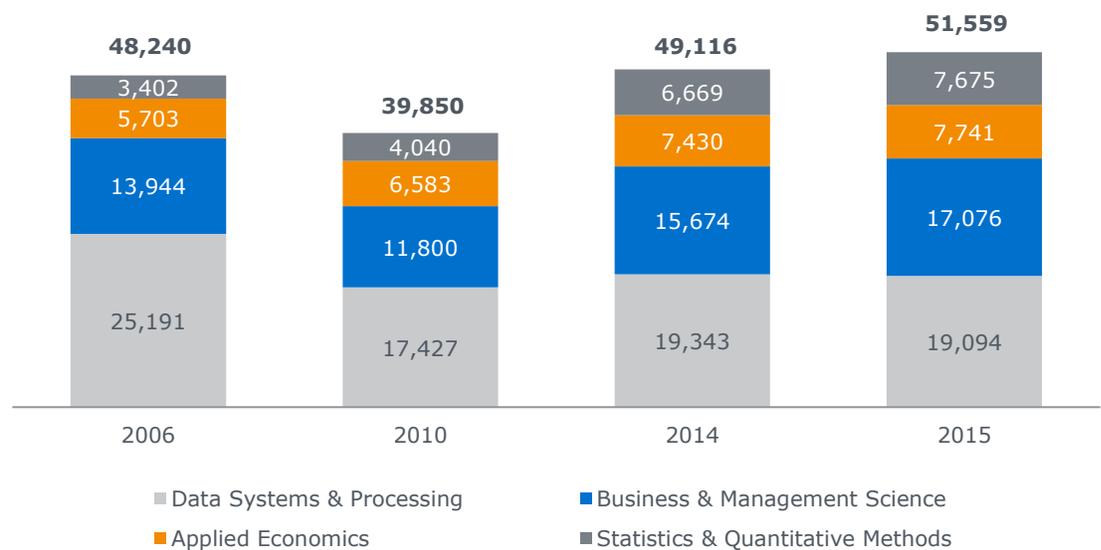
Limited Competition Indicates an Opportunity for the University of North Carolina-Charlotte to Launch a Bachelor’s-Level Data Science Program

Few institutions nationwide offer bachelor’s-level data science programs.⁶ Limited competition, coupled with growing demand for bachelor’s-level data science professionals, indicates a market for additional programs. Further, the master’s-level data science program at the **University of North Carolina-Charlotte** provides the University with infrastructure to launch a bachelor’s-level data science program. The Forum could not identify bachelor’s-level data science programs in North Carolina currently. However, the **University of North Carolina-Chapel Hill** [advertises](#) the possibility of a new bachelor’s-level data science minor.

National completions for programs related to data science and analytics grew seven percent between 2006 and 2015 (i.e., 48,240 to 51,559 completions). Although few institutions offer full bachelor’s-level data science programs currently, the number of bachelor’s-level data science programs increased in recent years. For example, **Western Michigan University** launched a bachelor’s-level data science program in 2015 to meet a rapidly growing need for data scientists. The **University of California-Berkeley** [plans](#) to launch a data science major and minor in the spring of 2018.

National Completions for Programs Related to Data Science and Analytics

National Center for Education Statistics, 2006-2015⁷



6) Shepherd University, [Intent to Plan](#)
 7) [National Center for Education Statistics](#)

Program Structure

[EAB research](#) indicates “data science” may be perceived as a more technically sophisticated branch of “data analytics.”

While Program Title and Location Vary, Bachelor’s-Level Data Science Curricula Remain Similar

Due to the emerging nature of the data science field, profiled bachelor’s-level data science programs range in title (i.e., “data science,” “data analytics”) and often reside in differing locations (e.g., college of arts and science, college of engineering). Bachelor’s-level data science curricula typically incorporate a similar mix of statistics, computer science (e.g., programming), and business administration coursework. The **University of Michigan** website describes the nature of the bachelor’s-level data science program as a combination of computer science and statistics. Similarly, **Utah Valley University** offers a mix of statistics, computer science, and business administration coursework such as “Business Intelligence Systems” and “Multivariate Analysis.” Two profiled programs (i.e., University of Michigan, **Western Michigan University**) exist as a collaboration between two colleges or schools, such as a college of engineering and a college of arts and sciences.

Modality

[EAB research](#) indicates a data science program could be **delivered in-person or online**. Five of six profiled institutions do not report program modality. **Southern New Hampshire University** offers a bachelor’s-level data analytics program fully online.

Characteristics of Existing Bachelor’s-Level Data Science Programs

Profiled Institutions

Institution	Program Title	Location	Modality	Required Credits
Bellevue College	Bachelor of Applied Science Degree in Data Analytics	Institute for Business and Information Technology	Not reported	45 credit hours
Western Michigan University	Bachelor of Science in Data Science	College of Engineering and Applied Sciences, College of Arts and Sciences	Not reported	45 credit hours
University of Michigan	Undergraduate Data Science Program	College of Engineering and College of Literature, Science, and the Arts	Not reported	42 credit hours
Columbia University	Bachelor of Arts in Data Science	School of Engineering and Applied Science	Not reported	24 points
Utah Valley University	Applied Data Analytics, Minor	College of Technology and Computing	Not reported	18 credit hours
Southern New Hampshire University	Bachelor of Science in Data Analytics	Science and Mathematics Program Online	Online	Not reported

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Committee on Envisioning the Data Science Discipline: The Undergraduate Perspective

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UNDERGRADUATE PERSPECTIVE**

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Preface

The National Academies of Sciences, Engineering, and Medicine established the Committee on Envisioning the Data Science Discipline: The Undergraduate Perspective to set forth a vision for the emerging discipline of data science at the undergraduate level (see Box P.1 for the committee’s statement of task).

BOX P.1 **Statement of Task**

A National Academies of Sciences, Engineering, and Medicine study will set forth a vision for the emerging discipline of data science at the undergraduate level. It will emphasize core underlying principles, intellectual content, and pedagogical issues specific to data science, including core concepts that distinguish it from neighboring disciplines. It will not consider the practicalities of creating materials, courses, or programs. It will develop this vision considering applications of and careers in data science. It will focus on the undergraduate level, addressing related issues at the middle and high school level as well as community colleges as appropriate, and will draw on experiences in creating master’s-level programs. It will also consider opportunities created by the emergence of a new science, technology, engineering, and mathematics (STEM) field to engage underrepresented student populations and consider ways to reduce the “leakage” seen in existing STEM pathways. Information gathering will center around two workshops, the first likely focused on principles and intellectual content, and the second likely focused on pedagogy and implications for middle and high schools and community colleges. To get material on the record quickly and spark community feedback, a rapporteur-authored workshop summary report will be issued following the first workshop. A final report will be issued following both workshops and committee deliberations setting forth a vision for undergraduate education in data science.

This study was sponsored by the National Science Foundation. The Committee on Envisioning the Data Science Discipline: The Undergraduate Perspective (see Appendix A for biographical sketches of the committee members) conducted a number of information-gathering activities and engaged a broad community in its conversations to address the statement of task shown in Box P.1 (see Appendix B for a list of the presentations given during these meetings and Appendix C for a list of those who contributed). In December 2016, the committee met to discuss possible future directions based on progress with current data science programs; societal implications of the evolving field of data science; approaches to expand diversity and inclusion in data science among students, staff, and topic areas; and perspectives on

envisioning the future of data science for undergraduates. In April 2017, the committee organized a webinar to collect further input from the public on topics of importance for this study.

In May 2017, the committee convened a workshop in which participants discussed educational models to build relevant foundational, translational, and professional skills for data scientists in various roles; the use of high-impact educational practices in the delivery of data science education; and strategies for broad participation in data science education that rely on formal modes of evaluation and assessment. Participants focused on the ways in which students, institutions, and programs could change in the coming decade, as well as how these changes will affect future plans for data science education.

The committee also held nine webinars throughout Fall 2017 as another means to engage the public in conversations about various aspects of data science education, which addressed the following topics:

1. Building data acumen;
2. Incorporating real-world applications;
3. Training faculty and developing curriculum;
4. Enhancing communication and teamwork skills;
5. Fostering interdepartmental collaboration and institutional organization;
6. Considering ethics;
7. Assessing and evaluating data science programs;
8. Emphasizing diversity, inclusion, and increased participation; and
9. Exploring 2-year colleges and institutional partnerships.

Although these nine webinars focused specifically on applications to data science programs, many of the discussions highlighted best practices relevant for all types of academic programming. The committee met for a final session in December 2017 to prepare for the writing of this report. During this session, the committee synthesized discussions from the webinar series and results from activities under way in the data science community. This final report, which was preceded by a September 2017 interim report, explores key questions about the future of the field of data science.

Summary

Data science is emerging as a field that is revolutionizing science and industries alike. Work across nearly all domains is becoming more data driven, affecting both the jobs that are available and the skills that are required. As more data and ways of analyzing them become available, more aspects of the economy, society, and daily life will become dependent on data. As a result, the National Academies of Sciences, Engineering, and Medicine was asked to set forth a vision for the emerging discipline of data science at the undergraduate level. To that end, the committee considered core underlying principles, intellectual content, and pedagogical issues specific to data science, including the essential concepts that distinguish it from neighboring disciplines. All of this was anchored in exploration related to applications of and careers in data science.

Today, the term “data scientist” typically describes a knowledge worker who is principally occupied with analyzing complex and massive data resources. However, data science spans a broader array of activities that involve applying principles for data collection, storage, integration, analysis, inference, communication, and ethics. In future decades, all undergraduates will profit from a fundamental awareness of and competence in data science.

Recommendation 2.3: To prepare their graduates for this new data-driven era, academic institutions should encourage the development of a basic understanding of data science in all undergraduates.

The continued transformation of work requires both a larger population with a basic understanding of data science and a substantial cadre of talented graduates with highly developed data science skills and knowledge, acquired through substantial coursework and practice.

Recommendation 2.1: Academic institutions should embrace data science as a vital new field that requires specifically tailored instruction delivered through majors and minors in data science as well as the development of a cadre of faculty equipped to teach in this new field.

The new majors and minors will initially combine ingredients from existing courses, in areas such as computer science, statistics, business analytics, information technology, optimization, applied mathematics, and numerical computing. Over time, as features of the new data-driven era take shape, academic programs will be compelled to develop new skill clusters, and a body of distinctive courses and instructional materials will emerge.

Recommendation 4.1: As data science programs develop, they should focus on attracting students with varied backgrounds and degrees of preparation and preparing them for success in a variety of careers.

Graduates of these programs will work in virtually every job sector and will serve in a number of roles, including operating the systems on which analyses are run, preparing data for analysis, defining and coordinating the analysis, visualizing information, and supporting data-driven decision making to uncover the stories buried in the data. Others who use data science skills will be journalists, administrators, artists, lawyers, teachers, and other workers who need some ability to understand and use data. This need to prepare diverse students for various careers further increases the educational challenge.

A wide variety of instructional programs will be needed to prepare students for the data-enriched world of the coming years.

Recommendation 2.2: Academic institutions should provide and evolve a range of educational pathways to prepare students for an array of data science roles in the workplace.

These include introductory courses, full degrees at both associate and bachelor levels, and a range of minors and certificates. The forms of these programs and their scope will vary depending on the culture of a given institution and the aims of its students.

Regardless of the type of program, certain elements need to be covered, though perhaps to varying degrees and with varying emphases. A key goal is to give all students the ability to make good judgments, use tools responsibly and effectively, and ultimately make good decisions using data. The committee defines this collection of abilities as “data acumen.” To that end, students will need exposure to material from multiple disciplines—notably, mathematical, statistical, and computational foundations—and they will need training in data acquisition, modeling, management and curation, data visualization, workflow and reproducibility, communication and teamwork, domain-specific considerations, and ethical problem solving.

The committee underscores the centrality of studying the many ethical considerations that arise as workers engage in data science. These considerations include deciding what data to collect, obtaining permissions to use data, crediting the sources of data properly, validating the data’s accuracy, taking steps to minimize bias, safeguarding the privacy of individuals referenced in the data, and using the data correctly and without alteration. It is important that students learn to recognize ethical issues and to apply a high ethical standard.¹

Recommendation 2.4: Ethics is a topic that, given the nature of data science, students should learn and practice throughout their education. Academic institutions should ensure that ethics is woven into the data science curriculum from the beginning and throughout.

Recommendation 2.5: The data science community should adopt a code of ethics; such a code should be affirmed by members of professional societies, included in professional development programs and curricula, and conveyed through educational programs. The code should be reevaluated often in light of new developments.

¹ For information about community efforts toward more transparent data-driven decision making for social good, see <http://datafordemocracy.org>, accessed March 12, 2018.

Academic institutions are stepping up to these educational challenges with a variety of programs and educational pathways. Several 4-year undergraduate institutions offer data science majors and/or minors—serving not only those students pursuing data science as a career but also those students who want to acquire data skills while majoring in another field. Two-year institutions are starting to introduce associate degrees and certificates in data science to prepare students to transfer to 4-year programs or to give them skills to compete in the workforce. Summer programs enable undergraduate students to build up data science skills rapidly. Boot camps and intensive training programs that aim to refresh or retool postgraduate students with the skills required of the growing data science workforce are now appearing. Massive open online courses in data science are proliferating and serve as stand-alone points of entry for all kinds of students (and flexible opportunities for professional development for instructors).

These pioneering examples of programs show what is possible, but there are significant challenges to developing data science programs more broadly and pervasively. The popularity of data science courses and programs will affect the entire academic institution by influencing enrollment, budgets, classroom allocation, computing resources, and scheduling. Institutions may need to consider how to create incentives for faculty in multiple departments and fields to collaborate to develop and deliver curricula that best meets students' needs. Today, there is a shortage of faculty in this rapidly evolving area. Enlisting and training existing faculty will be essential in the short term, and developing new faculty will be important in the long term. These challenges, among others, will need to be addressed to ensure the success of undergraduate data science students.

Recommendation 5.1: Because these are early days for undergraduate data science education, academic institutions should be prepared to evolve programs over time. They should create and maintain the flexibility and incentives to facilitate the sharing of courses, materials, and faculty among departments and programs.

The evolution of data science programs will be affected by a broad range of factors, including their initial home and structure, the needs and interests of students, and institutional culture. Although new programs could be launched by combining existing courses and materials, over time new classes and materials will need to be developed. Institutions will need to think through the pathways students are taking into data science and how to create bridges and remove barriers. Academic and career advising will be vital parts of data science programs; the advising programs will themselves need to evolve as the field and the market for graduates mature.

Data science itself provides the tools to continuously evaluate and improve data science education. Evaluation should include assessment of student learning and assessment of how well a program is meeting the needs of the market it aims to serve. Evaluation can be used to shape a program at a given institution, showing what is working and where improvement is needed. It can also be used comparatively to detect approaches, classes, or curricula that may be of value to other campuses or contexts.

Recommendation 5.3: Academic institutions should ensure that programs are continuously evaluated and should work together to develop professional approaches to evaluation. This should include developing and sharing measurement and evaluation frameworks, data sets, and a culture of evolution guided by high-quality evaluation. Efforts should be made to establish relationships with sector-specific professional societies to help align education evaluation with market impacts.

Much of the necessary data for evaluation could come from institutions' administrative records. These records, used in conjunction with other data sources such as economic information and survey data, could

enable effective transformation and generalization of programs and might even inform a cohesive national approach to undergraduate data science education.

In many fields, professional societies play a role in creating and nurturing community, in facilitating the sharing of resources and results, and in convening groups to set standards or determine best practices. Such capabilities are valuable to data science as well. However, it may be difficult for a single existing society to represent all the interests of the data science community. A structured collaboration of existing professional societies might work better, with potential development of sub-societies devoted to data science elements in any of many preexisting societies.

Recommendation 5.4: Existing professional societies should coordinate to enable regular convening sessions on data science among their members. Peer review and discussion are essential to share ideas, best practices, and data.

Conferences, workshops, training sessions, and other networking opportunities would benefit the joint communities. Other opportunities for the collaborating societies would be collecting materials; convening discussions around critical topics such as curriculum, evaluation, and ensuring broad participation; and potentially creating publication venues for the broad community. *As data science continues to evolve, it is essential that academic institutions and other stakeholders take steps to prepare students for a data-enabled world. The time to act is now.*