

Investing in America's data science and analytics talent

The case for action

April 2017



Increasingly US jobs require data science and analytics skills. Can we meet the demand? The current shortage of skills in the national job pool demonstrates that business-as-usual strategies won't satisfy the growing need. If we are to unlock the promise and potential of data and all the technologies that depend on it, employers and educators will have to transform.

This joint report from the Business-Higher Education Forum and PwC looks at eight actions for change to put the supply of skills in balance with the demand.

Eight actions for change

Responding to the supply-demand challenge



- 1 Hire for skills, not only diplomas**
Clarify demand with signals that motivate educators and job seekers
- 2 Be bold with investment**
Invest in market-driven programs that link learning with work

What business needs to change



- 3 Know the roles**
Structure your people plan for the digital economy
- 4 Prioritize lifelong learning**
Modernize training and development for long-term employability

What higher education needs to change



- 5 Create hubs, not silos**
Use data science to build multidisciplinary strength
- 6 Champion data literacy for all**
Enable all students to become data literate and open more routes to data science
- 7 Step up professional ties**
Strengthen alignment with societies that drive professional conduct
- 8 Design for inclusion**
Expand the pathways that lead to a diverse analytics workforce

The challenge is ours

The world is changing around us—and fast. Business leaders feel more pressure than ever to innovate and they're urgently searching for the people who can help their organizations adapt with agility and speed. At the same time, increasing portions of the workforce face skill obsolescence, reduced earning potential, and workplaces that demand more sophisticated technology and data analytics skills than ever before.

How can we best prepare students and the broader workforce for the opportunities and challenges that lie ahead?

Two years ago in our paper, *Data Driven*, we offered specific curriculum recommendations for universities to strengthen technical foundations in data analytics and related skills. Unlocking the value of data requires a diverse, multidisciplinary approach to problem solving, combining data science and analytical skills with functional and industry expertise, creativity, and leadership. Our development framework, the PwC Professional, is a holistic approach to preparing leaders who will shape the future, integrating technical skills with broader business and global acumen, communication and relationship skills, and whole leadership.

We also know that a key to success in business is a diverse workforce—teams, boards, organizations, customers, and stakeholders all benefit from diversity. Increasing the pipeline of minorities and women equipped with expertise in data sciences and technology is an imperative for business. And, as a society, we have an imperative to expand participation in the economic benefits of a data-driven, digital economy.

The mission of the Business-Higher Education Forum (BHEF) has never been more important. We hope this examination of data science and analytics workforce trends provides you with insights into the existing market, and how businesses and higher education must work together to enable individuals, our society, and economy to fulfill our full potential, and address the great challenges of the 21st century.



A handwritten signature in black ink, appearing to read 'Michael Fenlon'. The signature is fluid and cursive.

Michael Fenlon
Chief People Officer, PwC

Join us in creating solutions

Investing in America's Data Science Talent: The Case for Action provides groundbreaking data science and analytics (DSA) market intelligence informed by a Burning Glass Technologies workforce analysis and real-time survey data of business and higher education leaders from Gallup. The findings of this report document the emergence of the hybrid economy, in which companies in all sectors have become increasingly digital-intensive organizations.

The hybrid economy generates considerable demand for highly trained data scientists and an even greater demand for analytics-enabled professionals who possess hybrid skills: deep knowledge in a particular domain with strong ability in the use of data, analytics, and visualization tools. Despite this broad demand across all sectors, the US faces a significant shortfall in the number of data scientists and 'data-enabled' professionals. Closing this DSA talent gap—and enabling organizations to take full advantage of the value of data—will require significant expansion of strategic partnerships between business and higher education as well as investments in new talent development strategies.

The Business-Higher Education Forum has catalyzed dozens of such partnerships. As the nation's oldest membership organization of Fortune 500 CEOs, college and university presidents, and other leaders dedicated to the education of a highly skilled future workforce, our members form strategic partnerships to build new undergraduate pathways; improve alignment between higher education and the workforce; and produce a diverse, highly skilled talent pool to meet demand in emerging fields.

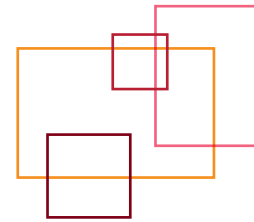
As demonstrated by existing BHEF members' DSA partnerships, strategic partnerships have the potential to rapidly transform the current workforce into one which meets the DSA talent demands of employers. They will need to address both new graduates as well as the incumbent workforce and span the range of DSA expertise needed by businesses, from entry level to expert.

Toward this goal, we partnered with PwC to publish a clear assessment of the current and future state of DSA workforce demand and higher education's response as well as recommendations for narrowing the gap for DSA talent. We hope the following pages will inspire you to take action and join us in building strategic business-higher education partnerships to develop the DSA talent, especially the DSA-enabled graduates, that our economy needs.



A handwritten signature in black ink that reads "Brian Fitzgerald". The signature is fluid and cursive, written over a light grey background.

Brian K. Fitzgerald, Ed.D.
CEO, Business-Higher Education Forum

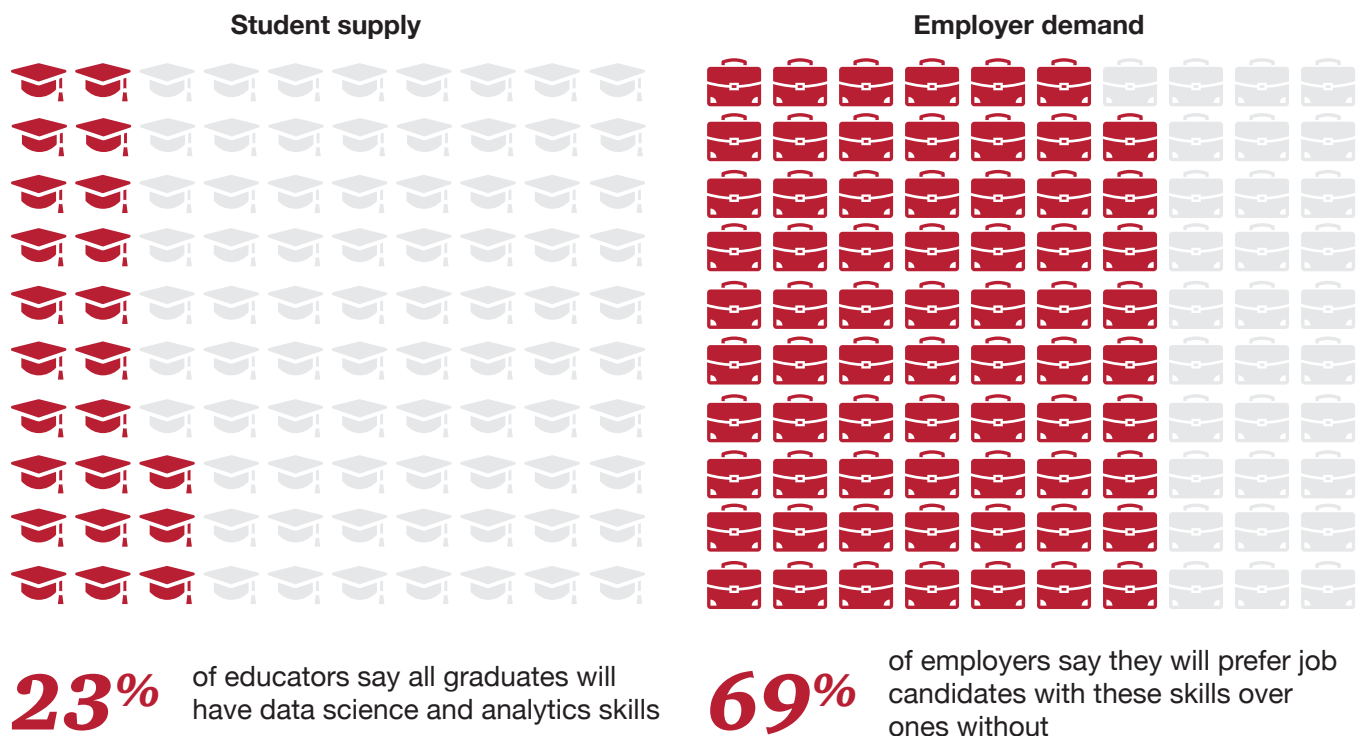


America's DSA skills imperative

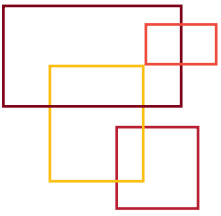
The current shortage of job candidates with data science and analytics (DSA) skills is likely to expand in coming years with negative implications for economic growth and competitiveness. A poll, conducted by Gallup for the Business-Higher Education Forum, revealed that by 2021, 69% of employers expect candidates with DSA skills to get preference for jobs in their organizations. Yet only 23% of college and university leaders say their graduates will have those skills.

The talent shortfall will not only involve data scientists, but it also will extend to existing job classifications from the C-suite to frontlines—all of which are increasingly enabled by analytics. As with the revolution in work brought on by the personal computer (PC) 30 years ago, data science and analytics, hand in hand with machine intelligence and automation, are creating a new revolution in work.

Figure 1: Data science and analytics skills, by 2021
The supply-demand challenge



Base: Higher education: 127; Business: 63
Source: Gallup and BHEF, *Data Science and Analytics Higher Education Survey* (December 2016).



Market dynamics will eventually close the DSA skills gap, but can US employers afford to wait? Like the PC revolution, businesses whose workforces do not have the skills necessary to wield data science and analytics will become also-rans in the race to capture the opportunities and value they offer.

To help support the competitiveness of US companies, PwC and the Business-Higher Education Forum studied the fast-growing demand for DSA skills. With the help of a Burning Glass Technologies workforce analysis, we examined current demand, and we commissioned two Gallup surveys to understand the future demand.

We found a fundamental disconnect. Employers will need data-driven, multidisciplinary teams to tackle their biggest problems and grasp their most promising opportunities. But this runs counter to an educational culture where both faculty and students devote little time outside of their own specialties. Employers, too, are contributing to the disconnect. Because they do not yet fully understand the nature of DSA skills, they are not reshaping their people strategies to support the acquisition, development, and retention of people with these skills.

This report details eight opportunities that educators and employers can pursue to bridge this disconnect. There is a challenge ahead, but we are convinced that by working in tandem, educators and employers can close the DSA skills gap and ensure the future competitiveness of American companies and workers.

The term analytics refers to the synthesis of knowledge from information. It's one of the steps in the data life cycle: collection of raw data, preparation of information, analytics, visualization, and access. Data science is the extraction of actionable knowledge directly from data through either a process of discovery, or hypothesis formulation and hypothesis testing.

Source: National Institute of Standards and Technology.

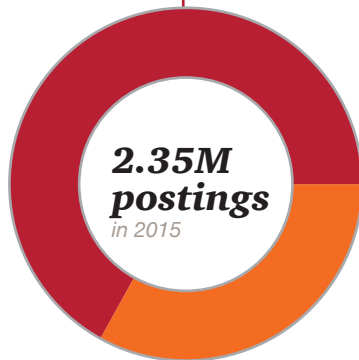
Demand for data science
and analytics skills?
New job postings to
reach **2.72M** in **2020**.

What does the jobs landscape look like today?



Analytics-enabled jobs

67%



Who are they?

Data-driven decision makers

Leverage data to inform strategic and operational decisions

Common job titles

Chief Executive Officer
Chief Data Officer
Chief Information Officer
Director of IT
Financial manager
Human resources manager
Marketing manager

Avg. advertised salary: \$91,467
Total job postings: 812,099

Functional analysts

Utilize data and analytical models to inform domain-specific functions and business decisions

Common job titles

Actuary
Business/Management analyst
Compensation/Benefits analyst
Financial analyst
Geographer/GIS specialist
HRIS analyst
Operations analyst
Researcher

Avg. advertised salary: \$69,162
Total job postings: 770,441

Data science jobs



23%

Who are they?

Data engineers

Design, build, and maintain an organization's data and analytical infrastructure

Common job titles

Business intelligence architect
Computer systems engineer
Data warehousing specialist
Data administrator
Database architect
Systems analyst

Avg. advertised salary: \$78,553
Total job postings: 558,326

Data analysts

Leverage data analysis and modeling techniques to solve problems and glean insight across functional domains

Common job titles

Data mining analyst
Business intelligence analyst

Avg. advertised salary: \$69,949
Total job postings: 124,325

Data scientists

Create sophisticated analytical models used to build new data sets and derive new insights from data

Common job titles

Biostatistician
Data engineer
Data scientist
Financial quantitative analyst
Statistician

Avg. advertised salary: \$69,949
Total job postings: 48,347

Note: 2.35 million US job postings from 2015. Actual salaries can be higher than what's advertised. We're showing just a small set of skills that get a premium.

Source: PwC analysis based on Burning Glass Technologies data, January 2017.

Skills that get a premium

Data-driven decision makers

Business intelligence • Business solutions • Cloud solutions • Data warehousing • Java • Product development • Product management • Software development principles

Functional analysts

Business development • Business intelligence • Business process analysis • Data mining • Microsoft development tools • Risk management • Software development principles • Systems design and implementation

Skills that get a premium

Data engineers

Big data • Cloud solutions • Data storage and protection • Data warehousing • Scripting languages • Operating systems • Optimization □ SQL and NoSQL

Data analysts

Big data • Data modeling • Data mining • Data visualization • Data warehousing • Extraction, transformation, and loading (ETL) • Operating systems • Optimization • Scripting languages • Software development principles • Statistical software

Data scientists and advanced analysts

Data modeling • Data mining • Data visualization • Extraction, transformation, and loading (ETL) • Machine learning • Mathematical modeling • Optimization • Scripting languages • Software development principles

By the numbers

Today's demand for data science and analytics skills

The market analysis calls for annual job openings to rise steadily to 2.72 million postings for data science and analytics roles in 2020. In 2015, there were more job postings asking for DSA skills than the total number of postings combined that asked for registered nurses and truck drivers, two of the largest hiring occupations in the US.¹

The demand for DSA skills is growing in all industries. Currently, the highest number of openings are in three sectors: finance and insurance, information technology, and professional, scientific, and technical services.

It's a mix of technical and social skills. These jobs are higher paying, but they also require higher levels of preparation and above-average social skills, analytical skills, or both.²

The available pool lacks diversity. DSA coursework attracts women and underrepresented minorities only marginally better than other STEM (science, technology, engineering, and mathematics) courses. STEM employment data show African Americans and Hispanics are consistently underrepresented (6% and 7% in STEM employment, respectively). Moreover, men consistently outnumber women by three to one.³

Business and higher education aren't on the same page. To build a pipeline of talent, business and higher education need better ways of signaling for the skills of the future. Eighty three percent of college and university presidents and provosts say a common skills framework would help them prepare students with the data science and analytics skills that they need in their jobs.⁴

State and private funding sources are untapped. Most data science programs in higher education are university funded, small, and newly minted. In our survey only 30% of university presidents and provosts say state funds support their programs in a significant way; 2% say private funding is a main source of support.

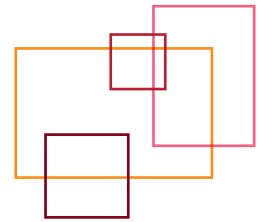
¹ Burning Glass Technologies (January 2017). Job post estimates include actual job growth, job replacements, and churn.

² Pew Research Center, "Jobs requiring preparation, social skills or both expected to grow most" (October 2016).

³ US Census Bureau, *American Community Survey* (September 2013).

⁴ BHEF and Gallup, *Data Science and Analytics Higher Education and Business Surveys* (December 2016).

Responding to the supply-demand challenge



Digital infrastructure is being built out in public and private spaces across the US. With it, our capacity to generate and transmit data from and across devices, entities, systems, and sensor networks (embedded in the Internet of Things) is growing exponentially.

Capacity, however, is only one of the essential enablers of digitization. Capability is essential, too, and that resides in the skills of people.

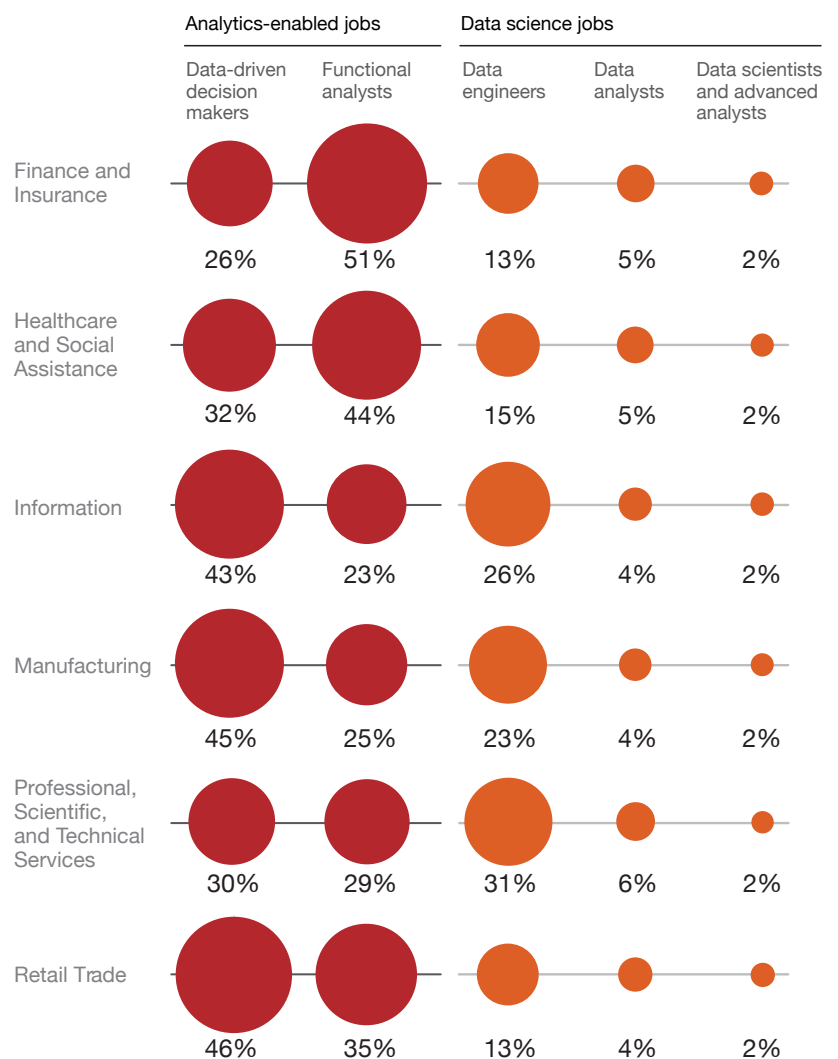
The market for DSA skills is hot, but it's full of mismatches. The time-honored practice of treating degrees as proxies for skill sets doesn't work with DSA. There is a growing number of DSA degrees and credentials—since 2010, 303 new accredited DSA programs were launched in the US, a 52% increase overall.⁵ But most of them have not been around long enough for employers to get a clear-eyed view of the viability of the job candidates they produce.

There is a far deeper pool of STEM talent, but here, too, it's often unclear how well prepared these job candidates are to use data science and analytics in business pursuits. Meanwhile, business schools have very few programs that include DSA coursework.

It is left to hiring managers and recruiters to determine how candidates meet skill requirements in this changing environment. To do that they need two things: 1) a common nomenclature to trade in DSA competencies and skills; and 2) a closer, more collaborative relationship with higher education aimed at creating programs that will provide job candidates with the skills they need.

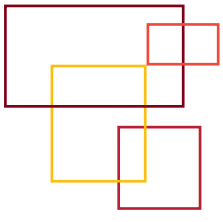
Figure 2: The demand is for business people with analytics skills, not just data scientists

Of 2.35 million job postings in the US.



Notes: Job category of analytics managers not shown. Totals may not equal 100%. Source: PwC analysis based on Burning Glass Technologies data, January 2017. Number of postings: Finance and Insurance (535,683); Healthcare and Social Assistance (100,000); Information (690,833); Manufacturing (237,484); Professional, Scientific, and Technical Services (511,947); Retail Trade (101,711).

⁵ Tableau, *The State of Data Education 2016* (November 2016).



1. Clarify demand with signals that motivate educators and job seekers

Consider a CEO who runs a non-profit organization working on microfinance. He can draw insights from unstructured social data and geospatial data like GPS data to figure out how to serve vastly different communities. He needs people who have foundational skills in computer science, math, and statistics, but also specific knowledge about each community so that patterns make sense in their right context.

Consider another CEO, this time of a biomedical company. She has access to massive amounts of neurological data from patients and thinks that mining this data could bring changes to how Alzheimer's is detected and treated. In this case, she needs workers with many of the same foundational data science skills, but who also know about working within the health system and many other social and economic factors that contribute to patient care.

To build a pipeline of talent that can tackle these and a broad array of problems in different industries, the people solving them need educators who can stage learning, helping students stack skills one on top of the next.

Most educators want this; 83% say a common skills framework would help them prepare students with the data science and analytics skills that they need in their jobs.⁶ That's why there's an organic movement to define and shape what students should know to prepare for careers that use DSA. This movement has two parts:

Skills frameworks for educators. The K–12 computer science framework helps educators design K–12 education programs that include data and analytics.⁷ It's based on a multistakeholder view of the concepts students should know and what they should be able to do with those skills. It's a huge step toward helping K–12 educators know what skills to focus on and how to advocate for student development throughout elementary, middle, and high school.

At the undergraduate level, the Business-Higher Education Forum has laid out a profile for the

foundational data science and analytics skills every graduate walking out of our colleges and universities should have. It's a vision for an 'enabled' graduate who has developed the skills that employers will value now and into the future. Colleges and universities can use the framework to guide curriculum choices including coursework for data literacy, communication of data, and how students can link data to business value.⁸

Skills frameworks for the data science profession.

The final piece is being able to see into data science and analytics as a profession, so that workers see the opportunities in front of them and know how their chosen educational paths can lead to their life's work. The European Union's EDISON project has created a framework that links skills to data science professions to help with that.⁹ The process to get there uses continual mining of data from job postings, college-level course offerings, and insights from business leaders.

In the area of data analytics and machine learning, EDISON researchers have identified skills common to data science occupations across broad skill groups:

1. Applied domain skills (research or business)
2. Data analytics and machine learning
3. Data management and curation
4. Data science engineering
5. Scientific or research methods
6. Personal and interpersonal communication skills

Employers shouldn't expect to find all of the above skills in one individual. Rather, they should use these skill groups as a guide to forming teams whose members collectively have a full skill set.

Eighty three percent of university presidents and provosts say a common skills framework would help them prepare students with the data science and analytics skills that they need in their jobs.

⁶ BHEF and Gallup, *Data Science and Analytics Higher Education Survey* (December 2016).

⁷ The K–12 Computer Science Framework at k12cs.org.

⁸ BHEF, *Competency Map for the Data Science and Analytics-Enabled Graduate* (November 2016).

⁹ EDISON *Data Science Framework* (October 2016).

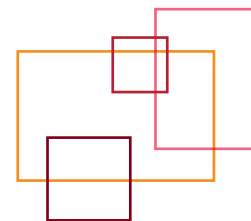
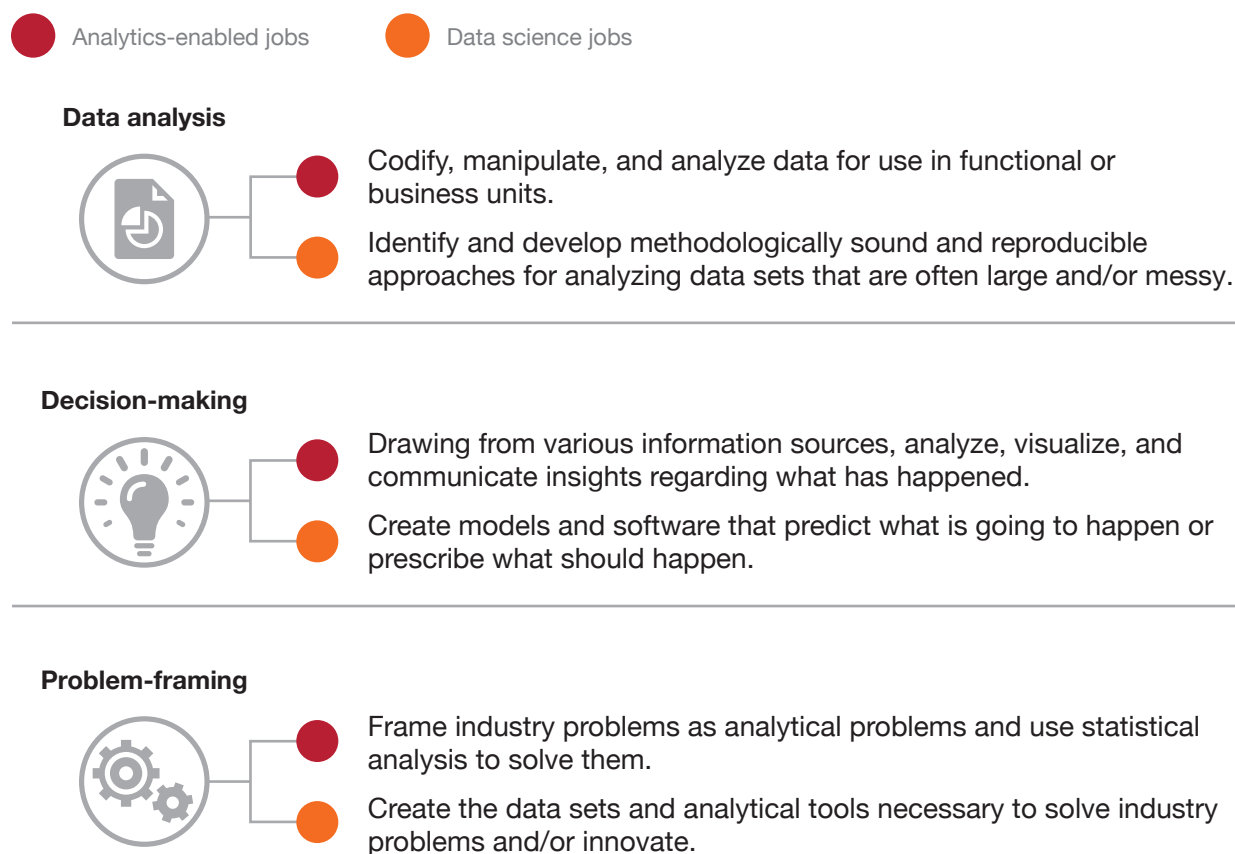


Figure 3: Similar skills, different job markets

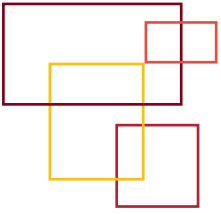
Analytics-enabled jobs, such as marketing managers and functional analysts, require some of the same foundational skills as data scientists, but they apply the skills in different ways.



Source: PwC and BHEF.

“The notion of what skills should be taught can vary widely. Within the college of engineering and the college of medicine, data science means different things. Finding a common thread can be a challenge.”

- **Raghu Machiraju**
Faculty director and co-lead of the Translational Data Analytics Program at The Ohio State University



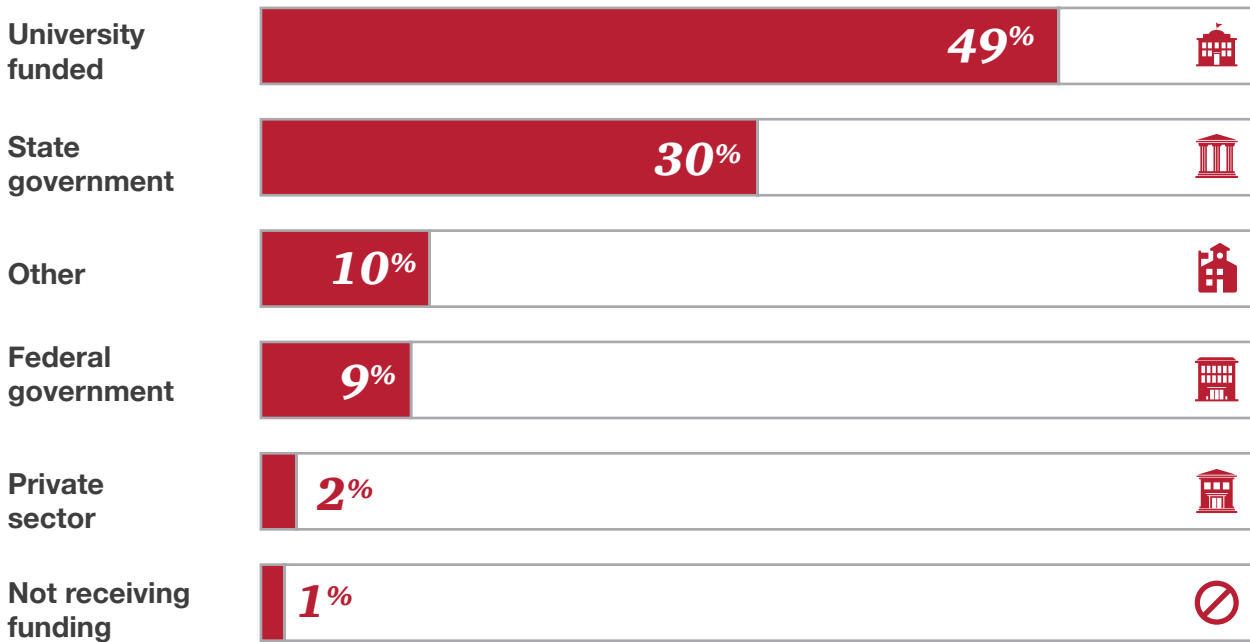
2. Invest in market-driven programs that link learning with work

Consider that most data science programs in higher education are university funded, small, newly minted and at the master’s degree level. Research labs and institutes are the most likely recipients of private funding, but the funding system often does not help build educational capacity throughout undergraduate programs.

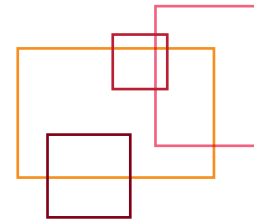
Many early master’s degree programs have been writing the formula for how to design an experience that reflects employer demand, making it easier for employers to back them or invest in starting something new. Still, few colleges and universities say private funding is a primary source of funding for DSA coursework (see Figure 4).

Figure 4: The private sector is a largely untapped resource for DSA program funding

Where is your university primarily receiving funding for data science and analytics programs offered to students at your institution?



Base: 127 College and University presidents, provosts, program chairs, and deans.
Source: Gallup and BHEF, Data Science and Analytics Higher Education Survey (December 2016).



Here's what employers can look for when investing or supporting a market-driven program. These programs should be:

- **Applied.** The most effective programs apply data science to real-world problems. The Advanced Institute for Analytics at North Carolina State University (NC State) accepts proposals from industry for a multidisciplinary, eight-month practicum. To date, the Institute has helped more than 100 companies tackle business problems.¹⁰
- **Experience-building.** Employers want candidates with experience. Northeastern University's Master of Data Science program offers students up to 12 months of pre-graduation work experience through co-ops and internships.¹¹
- **Aligned with the mission and academic reputation of the institution.** Educator-employer partnerships work best when the employer is aligned with the institutional mission and brand. Since its inception in 2014, The Ohio State University's Translational Data Analytics program has partnered with the private sector on grants and academics that fit with the institution's research to solve pressing problems. Some of their efforts are directed at using data science and analytics to reduce infant mortality in indigent

urban neighborhoods, accelerate drug discovery to fight disease, and realize autonomous systems for transportation and agriculture.¹²

- **Collaborative.** Educators should give employers an advisory role in curriculum development to ensure its relevance to industry. The Gallup poll revealed that 81% of higher education institutions that offer DSA coursework consult with industry during program development.¹³
- **Diverse and non-exclusive.** For employers, it's good to fight the temptation of exclusive partnerships. Companies should partner with multiple institutions to gain access to a diverse candidate base that will bring a wide range of backgrounds and experiences to work.

For educators, the creation of market-driven programs also means locating demand. Burning Glass Technologies' jobs assessment used natural language processing to reveal where DSA job density is highest and where the most DSA job postings appear (see Figure 5). By monitoring demand at this level, educators can make more informed funding decisions, as well as pinpoint areas where greater engagement with employers could have a significant impact on their efforts.

“We've recently launched a master's degree in computer science with a focus on data science with the University of Illinois. It's for potential data scientists who are unable to take a traditional education path by reimagining graduate-level education as a 'stackable' degree. It's also being offered at a fraction of the cost of a traditional on-campus master's degree.”

- Rick Levin, CEO, Coursera

¹⁰ North Carolina State University, Institute for Advanced Analytics, Practicum Sponsorship (accessed February 2017).

¹¹ www.northeastern.edu (accessed March 2017).

¹² The Ohio State University, *Translational Data and Analytics 2016 Status Report* (accessed February 2017).

¹³ BHEF and Gallup, *Data Science and Analytics Higher Education Survey* (December 2016).

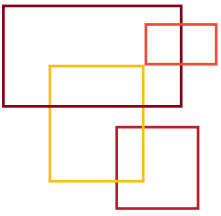
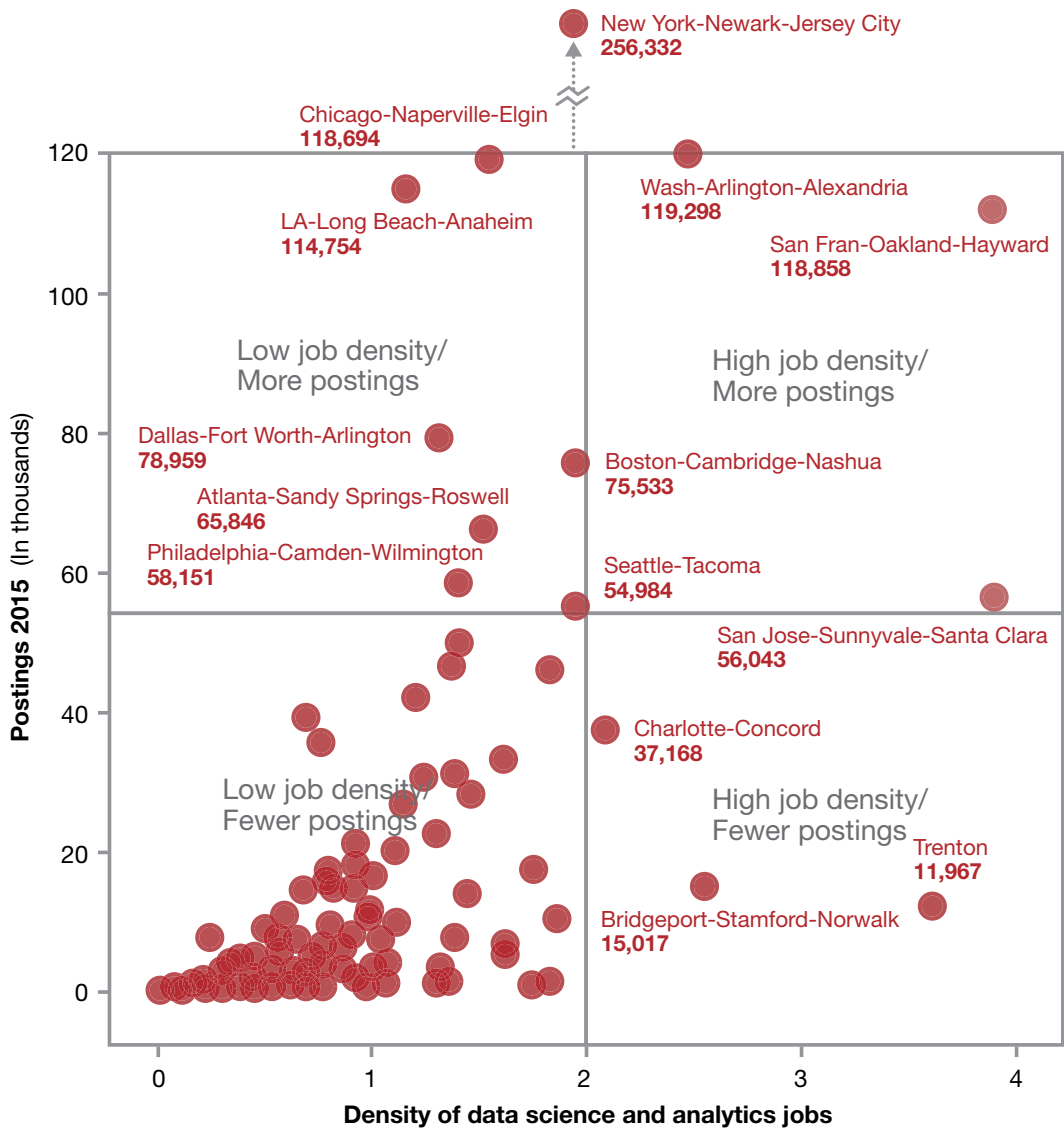


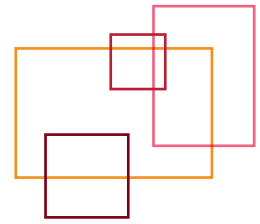
Figure 5: Where are markets booming for data science and analytics talent?

By monitoring demand at this level, educators can pinpoint areas where greater engagement with employers could have a significant impact.



Notes: We show a four-point scale, representing the sum of values for each job category.
 Source: PwC analysis based on Burning Glass Technologies data (January 2017).

What business needs to change



The ever-growing need for DSA skills requires employers to modify their people strategies. Witness Cisco Systems. As Cisco pivots from its mature business in switching and routing equipment to address the burgeoning opportunities in the Internet of Things, it is also realigning its people strategy. For instance, Cisco has partnered with the University of Washington and NC State to enroll hundreds of employees in a seven-month data science course. The goal: to foster a pervasive level of analytical knowledge across the company.¹⁴

Cisco is one example of how data science and analytics, and associated developments in machine learning and automation, will force employers to take a hard look at their workforces. When they do, they will see the need to modify the way they hire, who they hire, and how they organize, develop, and reward people.

Many companies have adapted some of their human resources practices to accommodate workplace innovations, but often, strategies and systems are essentially unchanged—even as new technologies are changing the nature of work. PwC’s 2017 Digital IQ research study found that strategic investments in digital technologies aren’t likely to live up to their potential unless companies align their people and cultures to their digital strategies in more systematic ways.¹⁵

The critical ability to apply DSA skills to both operations and innovations requires employers to take a closer look at people practices.

3. Structure your people plan for the digital economy

As the march of digitization continues forward, new approaches to recruitment and development will be needed. These approaches will be defined less by traditional career tracks and more by the set of DSA skills needed to build cohesive, multidisciplinary teams that can deliver business results.

An effective people plan must clearly define the skills and competencies for each role in a company, not just for data science teams, but for all the roles that are linked to those teams. A comprehensive plan requires an assessment of how to deliver people with the right skills, right knowledge, and right experience to the right places—now and in the next three to five years.

If you aren’t sure how to start thinking about your model or the people and skills you’ll need, there are translators who can help you. Lauren Andersen, executive director, NYC Tech Talent Pipeline, the city’s technology industry partnership, says employers know the problems that they want to solve, but they often don’t have a very accurate way of describing the skills they’re looking for. She says, “We help you ask: What business problems do people in these roles solve? What competencies do you need that can’t be easily taught? And what are the right qualifying filters to finding those things?”

Even within dedicated data science teams, there are a variety of roles. Data engineers make sure data is available and accurate. Data analysts work with business decision makers to understand what is happening or has happened in the data. Data scientists build predictive and prescriptive software and models, and they often work on long-term goals, such as developing corporate DSA capabilities.

Strategic investments in digital technologies aren’t likely to live up to their potential unless companies align their people and cultures to their digital strategies in more systematic ways.

¹⁴ Cisco Systems, “Preparing for the Data Science-Driven Era” (January 2016).

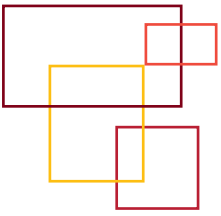
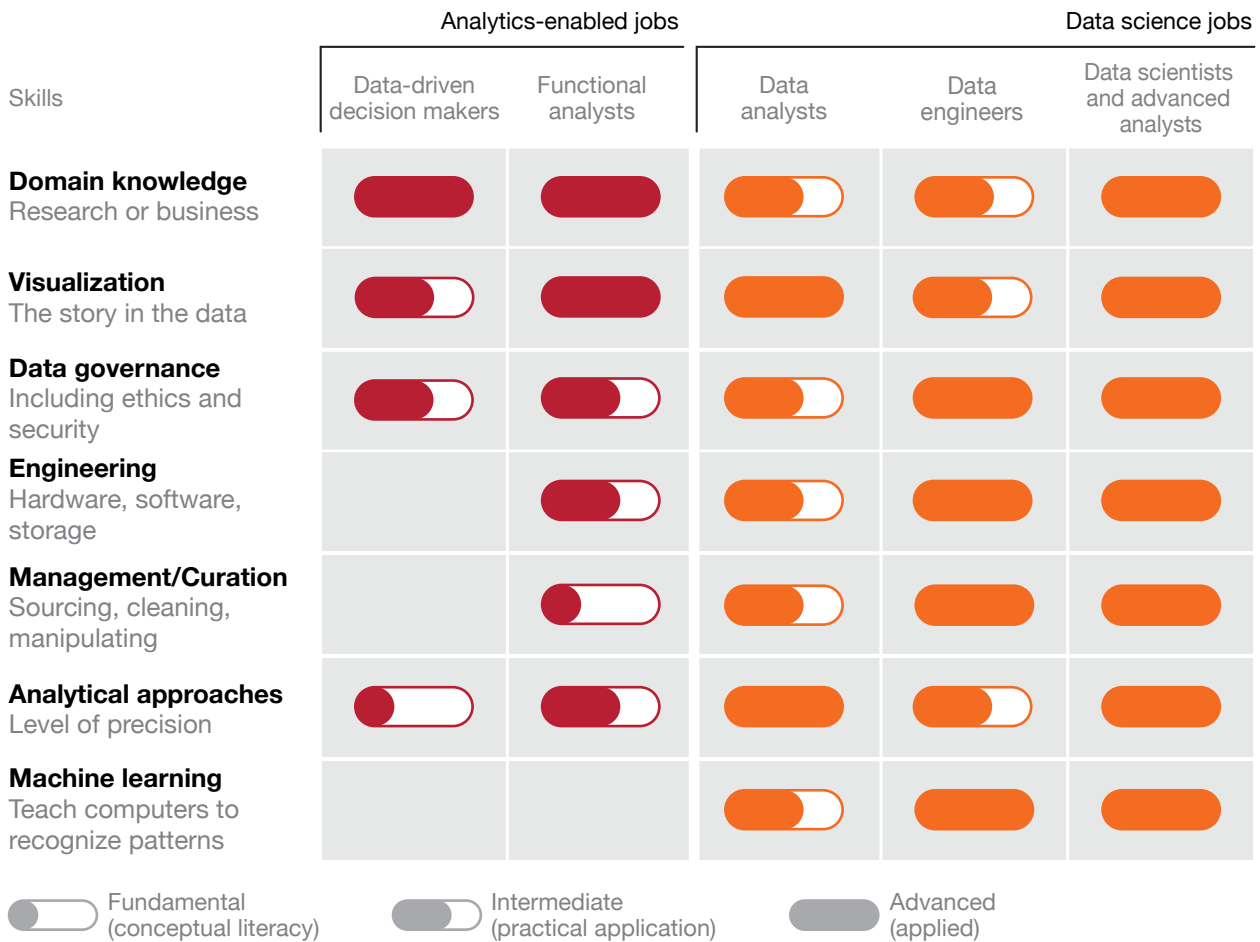
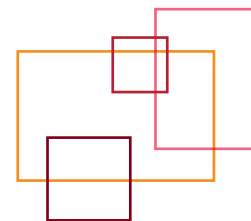


Figure 6: Layering DSA skills enables employers to better visualize roles

Use these skill groups as a guide to forming teams whose members collectively have a full skill set.



Source: PwC analysis based on Burning Glass Technologies data.



After employers define DSA roles, they can turn their attention to finding the people to fill those roles. Their success in this regard is dependent on the screens they use when sourcing talent. The best screening reduces the barriers to finding the right people. Sometimes, it achieves this by challenging traditional qualifiers and recognizing that candidates can have very valuable experiences outside of traditional paths. Employers can improve their screening in several ways, including:

- **Beware unconscious bias.** One of the reasons bias is so insidious is that it is often unrecognized. Now, software can help. SAP, for example, is applying machine learning to help companies prevent bias when screening candidates. Its programs flag words in job posts that indicate gender or ethnic biases, which, in turn, serve as obstacles to tapping a broader, more diverse pool of candidates.¹⁶
- **Don't overstate educational requirements; do consider alternative credentials.** Some jobs require degrees, but often, employers overestimate and overstate the need for degrees in their job postings. An effective talent plan identifies both primary and secondary job qualifications. It also identifies alternative credentials. Many companies are considering how a liberal arts education teaches students to approach complex challenges using critical thinking and problem solving, creativity, communication, and collaboration, for example. These free thinkers embody what business leaders say they will want long after some of the coding and data analysis tasks we know today are automated.
- **Use contests to spot talent.** Increasingly, we see companies turning to alternative venues for spotting talent, including challenge sites, hackathons, and other types of contests. Allstate finds candidates through challenges via Kaggle, a platform that hosts data science and machine-learning competitions. The insurer provides participants a data set and a problem to solve. The winners get a foot in the door with Allstate's hiring team.¹⁷

Because DSA skills and competencies can emerge and morph very quickly, employers should also consider new models for bolstering workforce readiness. These can include:

- **Create mentor-apprentice relationships.** PwC uses a mentor-led model for data science jobs. Candidates are hired for foundational skills in computer science, math, statistics, complex problem solving, and creativity. And, they are assessed on how likely they are to take initiative with good direction and to flourish in a mentor-apprentice relationship. Then, they receive guidance and training on-the-job from mentors. When Siemens USA found that less than 15% of 10,000 applicants had the skills in computing and mechanical engineering needed to pass its job screening, it turned to the time-honored practice of apprenticeships. In Charlotte, NC, Siemens began recruiting seniors from local high schools for a program that combines four years of on-the-job training with an associate's degree in mechatronics from nearby Central Piedmont Community College.¹⁸
- **Tap into talent exchanges.** Up to 35% of the US workforce, including a highly networked base of consultants, is engaged in freelance and contingent work. In response, some companies, including PwC, are vetting and curating an external network of independent workers. It is a model that enables employers to be more agile and innovative in the face of fast-changing market conditions and skill sets. But to make it work, many employers also will need to alter how they plan for talent, negotiate compensation, and create loyalty with this new type of worker.

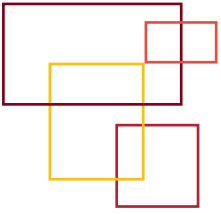
4. Modernize training and development for long-term employability

Recruiting from company ranks for data science and analytics skills is the best option for most. It's costly not to do this, both in productivity and in keeping up with attrition when skilled workers decide to look for better jobs. This will mean greater focus on updating skills as part of your culture, so that employees can focus on transferable skills and new skills as jobs change.

¹⁶ SAPVoice on "Forbes.com, Using Technology To Move Business Beyond Bias" (September 2016).

¹⁷ Allstate, Allstate Claims Severity Challenge on Kaggle (December 2016).

¹⁸ Siemens USA, "ICYMI - Wanted: Factory Workers, Degree Required" (February 2017).



“At Northrop Grumman, the key to developing new capabilities in our workforce is offering employees the opportunity to build skills in new technology areas, followed by job rotations and on-the-job development programs to apply and practice these new skills. Employees are motivated by the opportunity to expand their technical expertise and recognize the value of the investment that the company makes in their careers.”

- **Wes Bush**, Chairman, CEO and President of Northrop Grumman Corporation

Training and development are particularly relevant for existing roles that are becoming more analytics-enabled. When Gallup surveyed executives, about half of the respondents said that within the next three years, greater data and analytics skills will be required of everyone in operations, finance and accounting, and marketing and sales in their companies.¹⁹

Companies can bring all of the conventional training methods to bear on this challenge, including external degree and certificate programs, internal coursework, and on-the-job training. They also can adopt and adapt newer methods, such as Massive Open Online Courses (MOOCs) and bootcamps. Both of these training vehicles are well suited for working people who want to advance, but don't want or need to go back to school.

Companies can create their own MOOCs to put learning in context, or guide employees to preferred courses. PwC's courses for DSA on the Coursera platform, for example, can be taken by anyone. The courses are designed to provide practical, entry-level skills in data analysis, and presentation and visualization skills.

Corporate trainers could upskill more people, faster, with MOOCs or bootcamps if they had an easier time of sorting out which courses individuals should take. Right now there's no way to see how well courses are designed to deliver workplace or other competencies. Mapping courses to competencies could help employers signal what they want. First, they could name the competencies that spell out success for a job. Next, they could give employees a set of individualized course options that would help them build these skills.

Figure 7: Options to add competencies and skills

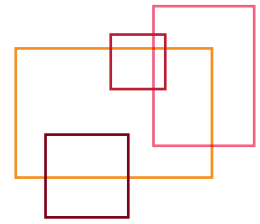
What levels of data science or analytics are needed?

	Conceptual literacy	Practical application	Advanced data science
Degree or certificate	Certificate or a series of short courses	Major, minor, concentration, or master's degree	Graduate degree; research fellowship
MOOCs and bootcamps	A short-course series on data analytics concepts	A multicourse series or bootcamp that leads to specialization	MOOCs and bootcamps aimed at STEM professionals
Corporate development and training	Training on how to use data to drive decision-making	Training tailored to your job function	Rarely delivered by corporate trainers
Job rotation, co-op, or internship	Rarely used	Option for applying theory to a real-world problem	Option for hands-on learning

Source: PwC and BHEF.

¹⁹ BHEF and Gallup, *Data Science and Analytics Higher Education Survey* (December 2016).

What higher education needs to change



DSA is a catalyst for change and innovation within universities not just because it is creating new professional disciplines, but also because it is altering so many established disciplines.

As such, DSA can be seen as part of a broader set of trends that are challenging colleges and universities to:

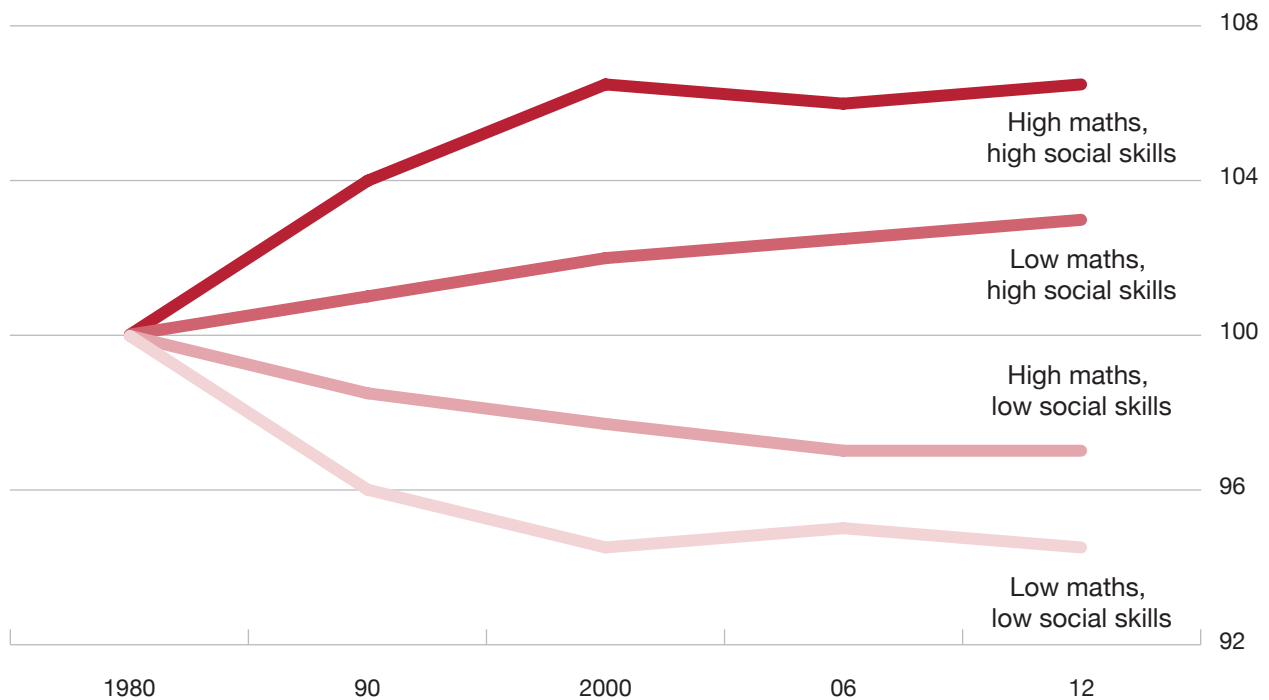
- Change curriculums to meet skill needs
- Structure degrees and credentials for individual paths
- Provide a high-quality education at a reasonable cost
- Partner more frequently with employers
- Invest in their reputations for applied research

While university-branded MOOCs, bootcamps, and hackathons help universities meet some of these challenges, DSA skills can be learned outside of the university setting, so students want compelling reasons to commit to a university program.

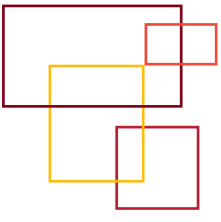
This challenge is making it harder for all but those institutions with existing reputations for excellence in engineering and computer science to create attractive DSA programs. Still, the demand for these skills is expanding so dramatically that more preparation, not less, is required for students to qualify for higher-paying jobs (see Figure 8). All colleges and universities should be providing students with foundational DSA skills.

Figure 8: The fastest-growing job areas require both analytical and social skills

US, change in employment skills by skills required, 1980 = 100



Source: David Deming, "The Growing Importance of Social Skills in the Labor Market," August 2016.



5. Use data science to build multidisciplinary strength

A very large part of the DSA skills story is often missed: Competency in DSA includes the ability to thrive in multidisciplinary teams. The ability to apply data science and analytics in healthcare, for example, means driving outcomes that touch doctors, nurses, patients, and administrators. To achieve this, educators need to provide a program that brings industry, health policy, computer science, and data science together through a diverse range of skills, expertise, and experience.

And the need for multidisciplinary applied problem solving is how early data science institutes got their start. Columbia University's Data Science Institute, for example, got its start based on the need to solve important problems and grow the local economy in New York City. In response, Columbia structured its institute around multidisciplinary education, research, and outreach to industry. Their educational program began with a new curriculum in the foundations of data science, designed in part by Professor Chris Wiggins, who is both a member of the institute as well as chief data scientist at *The New York Times*. Foundations of data science forms the training core of the institute, and it develops students who can then branch out to drive research via the Institute's applied centers throughout nine different schools including the schools of business, journalism, law, engineering, and the Columbia University Medical Center.

The DSA institute concept is evolving in new programs in Europe. The Amsterdam School of Data Science links over 600 scientific researchers and connects disciplines, research institutes, and industries together to work on data science problems. Its students can choose from 270 different courses from four different regional universities to help them build the specializations they desire.²⁰

The opportunity to apply data science to a real-world problem enables students to develop a host of other much-needed workplace skills. They engage in critical thinking, get creative, communicate effectively, and collaborate with a diverse range of people—all of which develop the 'social' skills that are becoming increasingly important in data science and analytics.

These experiences help develop 'T-shaped' individuals, whose principal competency, plus well-honed social skills, allow them to cross functions and domains. Of course, these are the same skills that employers are searching for in job candidates and finding in short supply (see Figure 9).

The opportunity to apply data science to a real-world problem enables students to develop a host of other much-needed workplace skills.

²⁰ www.schoolofdatascience.amsterdam (accessed March 2017).

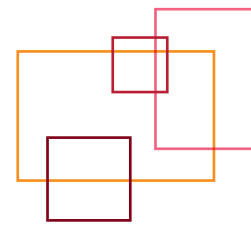
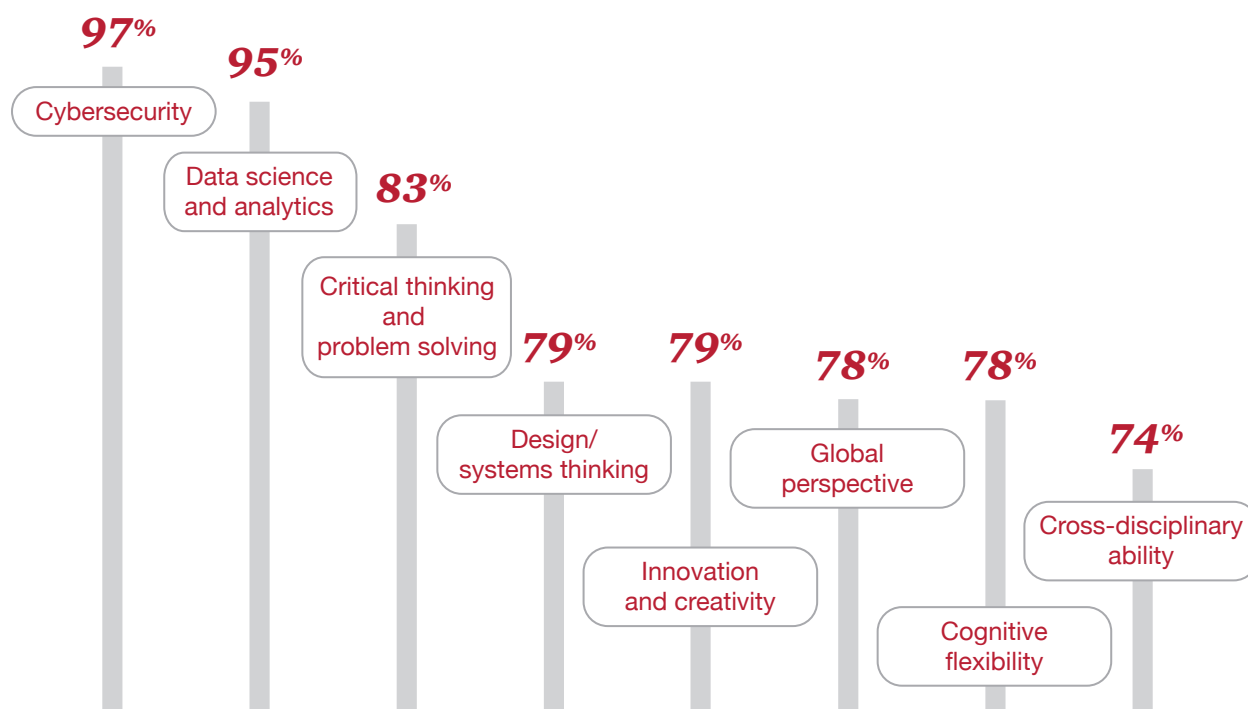


Figure 9: Skills that are tough to find
Percent of employers who say these skills are problematic to find



Source: Business Roundtable (2017).

6. Enable all students to become data literate and open more routes to data science

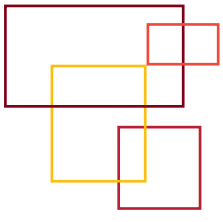
While there are many pockets of DSA excellence in higher education, the broader system doesn't yet recognize the growing role of DSA coursework in a broad range of career paths. The Gallup poll of educators revealed that less than a quarter (21%) of the university presidents and provosts whose schools offer data science and analytics courses require DSA coursework in all mathematics and science majors. In business schools, DSA coursework is required for only 30% of majors.²¹

All majors should require some foundational knowledge of analytics and the data science process. Data

visualization is a good example of such knowledge: It fuses art and science, helping students use data to express themselves in creative ways. This represents an enormous opportunity for educators because it is relevant to students in and outside of traditional STEM paths.

The goal of educators should be the design of a foundational DSA skills curriculum for all STEM and non-STEM majors that underscores the need for self-management of skills as technology changes. John Wiley and Sons, a global publisher of educational content, is developing a basic curriculum to help colleges teach these concepts across a wide range of learners. Wiley's program is based on the idea of the analytics-enabled graduate and emphasizes analytics, problem solving, critical thinking, and professional skills.

²¹ BHEF and Gallup, *Data Science and Analytics Higher Education Survey* (December 2016).



Educators should open more routes to data science jobs, too. Undergraduate students who want to pursue DSA coursework have too few opportunities. Undergraduates in computer science and engineering, for example, are rarely able to layer on specialties in data science through minors or certificates, even though they presumably would be receptive to such an opportunity.

Drake University is one school that has recognized the importance of opening DSA paths for undergrads. It offers students in any undergraduate field of study an opportunity to enhance their degree with a minor in data analytics. Students on this track develop basic DSA skills and proficiencies through six courses in math, statistics, and computer science.²²

7. Strengthen alignment with societies that drive professional conduct

How different occupations use data science is set to grow quickly in the next three years, even as principles for what this means are not well understood (see Figure 10).

Today, employers sometimes find employees are missing an understanding of where and how to source data or how messy it may be. If turnover occurs, employers may have troubles with validating empirical methodologies and reproducing analysis. This changes the risk profile for business and raises the need for good data governance and standards.

Educators can work closely with professional societies and in particular those serving math, engineering, humanities, social scientists, computer scientists, as well as specific domains like finance, health, and government. The goals are to champion opportunities to apply data science in research and course teaching, create bodies of knowledge, foundations for accreditation, and support and development for faculty. Longer term, professors will want to know the issues companies are facing, including what it means to be practicing, issues related to bias, data privacy, intellectual property, appropriate use, and regulatory concerns. Top of mind for all is how DSA is opening up new career paths and what jobs may emerge.

It's likely that each field will develop its own committees and standards, but there are benefits to having some common principles. A common language, particularly around DSA competencies and skills, can open up new avenues in higher education for working across departments. It can help students understand which paths are open to them. For employers, this common language can help with hiring, development, and training.

Chris Wiggins has a unique perspective on the benefits of spending more time learning about the jobs waiting for graduates. As both professor for Columbia University's Data Science Institute and chief data scientist for *The New York Times* he sees some misunderstanding of needed specializations which industry has developed. "Too often in academia," he says, "I'll hear in one sentence several terms that should be used separately to describe a data scientist, a data analyst, or a data engineer. In industry, these are separate collaborators who do different things."

8. Expand the pathways that lead to a diverse analytical workforce

When solving complex, non-routine problems, it's more effective to have diverse teams. And when it comes to data science and analytics, a diverse pool of job candidates is exactly what employers say they want yet struggle to find (see Figure 11).

Today, only 12% of university presidents and provosts agree that DSA courses attract more underrepresented minority students than other STEM courses.²³ In computer science and engineering—potentially the most receptive groups to growing DSA skills—few have clear paths building the skills employers want. If we look to STEM employment as a proxy for what the future could look like in data science it's not encouraging, US Census data shows African Americans, Hispanics, and women are consistently underrepresented (6% are African American and 7% Hispanic in STEM employment). Men consistently outnumber women three to one as computer workers.²⁴

²² BHEF, "Equipping Liberal Arts Students With Skills in Data Analytics" (2016).

²³ BHEF and Gallup, *Data Science and Analytics Higher Education Survey* (December 2016).

²⁴ US Census Bureau, *American Community Survey* (September 2013).

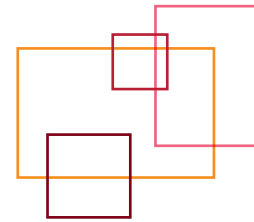
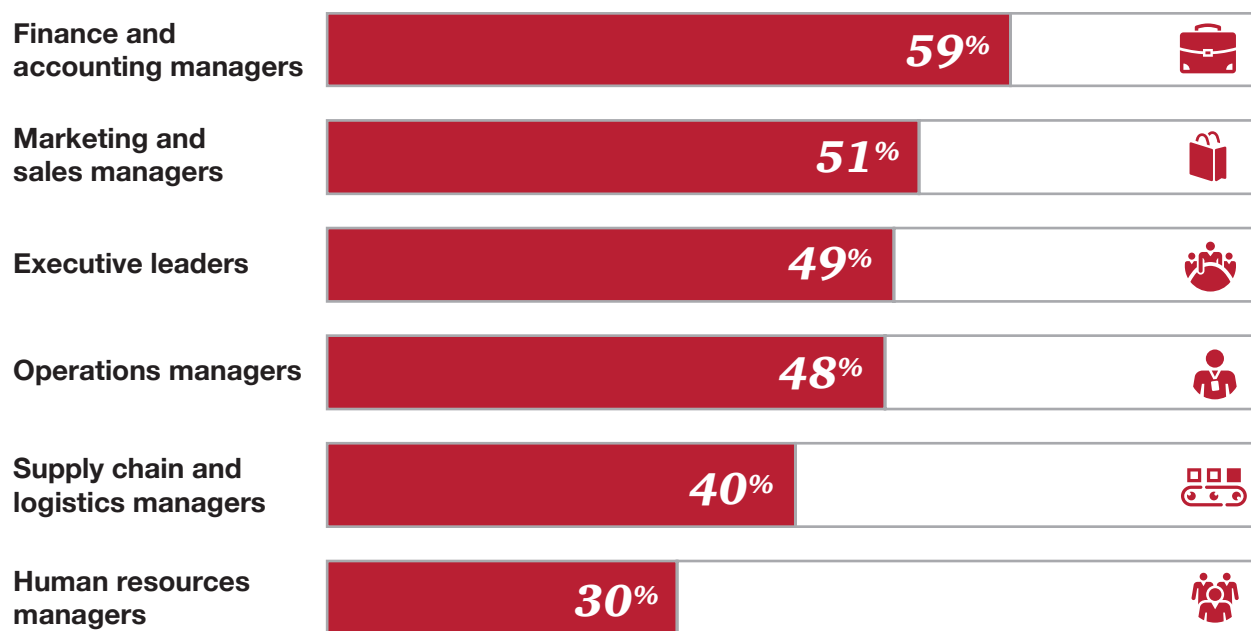


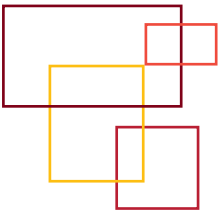
Figure 10: Data-savvy managers wanted

Percent of employers who say data science and analytics skills will be 'required of all managers' by 2020



Base: 63 US business leaders

Source: BHEF and Gallup, *Data Science and Analytics Business Survey* (December 2016).



The lack of diversity in data science is not only an employer problem, but also a national problem. The US economy has much to gain by engaging more of its workers in high-demand occupations—and data science, along with computer services and engineering, represent fast-growth categories of higher-paying jobs. To get a sense of what that might mean in macroeconomic terms, consider this: If female employment rates in the US rose to the level of Sweden (the leader among OECD countries), US GDP would grow to \$1.8 trillion, almost 10% larger than it is now. If more 20–24-year-old Americans entered into education, employment, or training, the US GDP could be higher by \$464.2 billion (a 2.5% boost).²⁵

Educators can foster greater diversity in data science and analytics in a variety of ways. Some of them are as follows:

- **Training and support for faculty.** The chair of Computer and Information Sciences at Spelman College was awarded a \$400,000 grant to provide DSA training to faculty members at Spelman and Morehouse colleges. Participating faculty will develop and implement the DSA coursework for undergraduates in an effort to boost DSA awareness among underrepresented minorities.²⁶
- **Teaching foundational DSA skills in a broad number of degrees.** Business degrees are the most sought after degree by women, so opening paths through minors or certificates can create new avenues into analytics-enabled jobs where few exist today.
- **Creating engaging introductory courses.** To help make computer science courses more attractive, Harvey Mudd College redesigned an introductory course requirement to emphasize practical uses for programming and team-based projects. They switched from the Java programming language to Python, which more closely mimics the way humans communicate. The course is broken into three tracks, including one for students with no programming background. At the school, 55% of computer science undergraduates are women, compared with 16% nationally.²⁷
- **Designing curriculum for practical use.** North Carolina State’s Institute for Advanced Analytics class of 2017 is 43% women and the class represents 19 countries of origin. Part of the success for this level of recruitment is its reputation for a practical hands-on degree that mirrors the day-to-day work of data scientists.²⁸

Figure 11: How can educators help employers with this challenge?

We struggle to find qualified data scientists who are...



Source: Business Roundtable (2017).

²⁵ PwC, *Women in Work Index and Young Workers Index* (October 2016).

²⁶ Spelman College, “Robust 2016 Funding Fuels Spelman’s Rigorous Research, Programs, and Initiatives Focused on STEM” (January 2017).

²⁷ Quartz, “Harvey Mudd College took on gender bias and now more than half its computer-science majors are women” (August 2016).

²⁸ North Carolina State’s Institute for Advanced Analytics, 2017 Student Profile (accessed March 2017).

Conclusion

The current shortage of DSA talent in the national job pool demonstrates that business-as-usual strategies won't satisfy this demand. If we are to unlock the promise and potential of data and all the technologies that depend on it, employers and educators will have to act.

The ability to use data and analytics is not only changing jobs, but it is leading us to ask more questions about established institutions and their legacies. What is the responsibility of business to their workers? How much should educators teach for workplace skills? How is data shifting the power structures in our organizations?

While the skills gap is our focus now, we must also recognize the bare fact that workplace skills are in flux and will remain so. To accelerate the development of DSA-savvy workforces, employers and educators will need to work together to construct skills frameworks that will

provide a sound foundation for DSA education and invest in launching educational programs that are aligned with evolving needs. Educators will need to create innovative, new programs capable of producing a diverse pool of data-enabled job candidates. Employers will need to refocus and reshape their people strategies and systems to recruit, develop, and retain DSA talent.

The stakes are high. Employers and educators must equip the American workforce with the skills they will need for a data-driven, digital economy. It is a shared responsibility to broaden access to the economic benefits to more members of our society and solve the challenges of the 21st century.

With this joint report, we respectfully extend an offer to help in this effort and an invitation to employers and educators who wish to collaborate.

About the jobs market analysis

Burning Glass Technologies, a labor market analytics firm, structured the data discovery for the US jobs market. Their task was to build a portrait of the demand for skills in data science and analytics. To achieve this, Burning Glass mined over 26.9 million job postings from 2015, the latest full year of available data, to identify:

- Key roles in the data science and analytics job ecosystem
- 300+ analytical skills requested in the labor market
- Occupations that commonly require a mix of these skills
- A jobs category for each occupation, to determine the links between types of jobs and education and skill levels

The final data set represents 2.35 million US job postings, in which employers are seeking candidates with data science and analytics skills. It does not include hidden markets, unposted positions, or gig economy jobs. It does not factor for the automation of routine tasks. A sixth jobs category, the analytics manager, is not shown; it represents 1.7% of data science and analytics jobs.

About the surveys

Both surveys were conducted by Gallup for BHEF. To qualify, respondents needed to be either knowledgeable about their company's hiring practices for data science or, in the case of higher education, have a data science program in place. In both surveys, 'data science and analytics skills' were defined as the skills needed to discover, interpret, and communicate meaningful patterns in data.

For the higher-education survey, Gallup conducted 127 phone interviews from October 31, 2016–March 1, 2017, with college and university presidents, chancellors, provosts, and deans from public and private, two-year and four-year, institutions which have data science and analytics programs. The sample is not nationally representative of US colleges and universities.

For the business survey, Gallup conducted 63 phone interviews from October 31, 2016–March 1, 2017, with business leaders. The sample consisted of a broad range of hiring titles (chief executive officers, chief information officers, chief technology officers, human resources officers, and vice-presidents of human resources) and a cross-section of industries (oil and gas, finance, insurance, computer systems, manufacturing, information, biotech, healthcare, retail trade, and transportation and warehousing companies). The annual revenue threshold was revenues of \$10 million or more. The sample is not nationally representative of US companies in these industries.

Acknowledgements

PwC and the Business-Higher Education Forum would like to thank the following people for their time and generosity in sharing their ideas and insights for this report.

Sean C. Ahearn

Ph.D. Co-CEO
BigKnowledge LLC

Lauren Andersen

Executive Director
NYC Tech Talent Pipeline

Wes Bush

Chairman, CEO and President of Northrop Grumman Corporation

Paul Blase

Global & US Consulting Analytics Leader, PwC

Lydia Cheng

Product Design Manager, John Wiley and Sons

Yuri Demchenko

Senior Researcher, System and Networking Engineering Group, University of Amsterdam

Dorinda Gallant

Faculty in Residence, Translational Data Analytics program, The Ohio State University, Associate Professor of Quantitative Research, Evaluation and Measurement

Rick Levin

CEO, Coursera

Dane Linn

Vice President, Business Roundtable

Raghu Machiraju

Faculty Director and Co-Lead Translational Data Analytics program, The Ohio State University, Professor of Bioinformatics and Computer Science & Engineering

David Meer

North American Leader, Advanced Customer Analytics, Strategy&

Steven Miller

Global Leader of Academic Programs, IBM Data & Analytics

David Mongeau

Program Director and Co-Lead, Translational Data Analytics program, The Ohio State University

Andrew Tein

Vice President, John Wiley and Sons

Chris H. Wiggins

Associate Professor of Applied Mathematics at Columbia University's Data Science Institute, and Chief Data Scientist at *The New York Times*

Editorial team:

Cristina Ampil, Managing Director, Integrated Content Leader, PwC

L. Isabel Cárdenas-Navia, Director of Emerging Workforce Programs, Business-Higher Education Forum

Karen Elzey, Vice President, Business-Higher Education Forum

Michael Fenlon, Chief People Officer, PwC

Brian K. Fitzgerald, Chief Executive Officer, Business-Higher Education Forum

Debbie Hughes, Vice President of Higher Education and Workforce, Business-Higher Education Forum

Special thanks to:

William Cudney, US People & Organization Practice, PwC

Dee Hildy, Integrated Content, PwC

pwc.com/us/dsa-skills

To have a conversation about issues related to the data science and analytics workforce, contact:

Michael Fenlon

Chief People Officer, PwC

(646) 471-1214

michael.fenlon@pwc.com

Brian Fitzgerald

CEO, Business-Higher Education Forum

(202) 367-1268

brian.fitzgerald@bhef.com

Debbie Hughes

Vice President, Higher Education and Workforce

Business-Higher Education Forum

(202) 367-2374

debbie.hughes@bhef.com