IS Programs Responding to Industry Demands for Data Scientists: A Comparison between 2011 – 2016

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ABSTRACT

The term data scientist has only been in common use since 2008, but in 2016 it is considered one of the top careers in the United States. The purpose of this paper is to explore the growth of data science content areas such as analytics, business intelligence, and big data in AACSB Information Systems (IS) programs between 2011 and 2016. A secondary purpose is to analyze the effect of IS programs' adherence to IS 2010 Model Curriculum Guidelines for undergraduate MIS programs, as well as the impact of IS programs offering an advanced database course in 2011 on data science course offerings in 2016. A majority (60%) of AACSB IS programs added data science-related courses between 2011 and 2016. Results indicate dramatic increases in courses offered in big data analytics (583%), visualization (300%), business data analysis (260%), and business intelligence (236%). ANOVA results also find a significant effect of departments offering advanced database courses in 2011 on new analytics course offerings in 2016. A Chi-Square analysis did not find an effect of IS 2010 Model Curriculum adherence on analytics course offerings in 2016. Implications of our findings for an MIS department's ability to respond to changing needs of the marketplace and its students are discussed.

Keywords: Big data, Data analytics, Visualization, Business intelligence, Model curricula

1. INTRODUCTION

Data scientists, big data, and analytics, to use a "Twitter-esque phrase, [are] what's trending now" (Agarwal and Dhar, 2014, p. 443). Nevertheless, many of the elements of these concepts are not new. Indeed, humans have analyzed data since the age of antiquity, and statistics as a discipline has existed since at least the middle of the 18th century. Analyzing data using a variety of statistical, arithmetic, machine learning and other methods, though more recent, have been occurring for some time. By the middle of the 20th century, decision makers used data to make production more efficient, reduce costs, and target more likely customers.

One might wonder what is different with "big data" then. The overriding difference is that there are new challenges, questions, and opportunities created by the availability of large data sets and technology that can process the data (Agarwal and Dhar, 2014). Surprisingly, the term 'data scientist' has only been in common use since 2008, and yet is already ranked as the number one career in the United States for 2016 (Breslin, 2016; Glassdoor, 2016).

The growth explosion in the arena of data science and big data is based on at least three significant modernizations. First, technology infrastructure has improved to the point where literal terabytes of data can be received and synthesized in real time (Silva et al., 2014). Second, advances in data storage, transformation, and manipulation tools have kept up with the pace of technology infrastructure improvements such that organizing these vast quantities of data is feasible. Third, the vast expansion of analytical tools and techniques from a variety of disciplines is impressive (Chen, Chiang, and Storey, 2012; Davenport, Barth, and Bean, 2012). These tools and techniques include business intelligence, data mining, statistical inferences, predictive analytics, visualization, and text analytics. These three modernizations facilitate utilizing vast quantities of data arriving in real time and just as quickly, making better decisions.

McKinsey Global Institute (MGI) studied multiple industries in Europe and the United States to examine the impacts of big data (Manyika et al., 2011). In the healthcare industry, they concluded that big data could create value or save costs of more than $300 billion with the possibility of $600 billion in added value. In the retail sector, MGI found that retailers using big data could easily increase their operating margins by more than 60 percent. Based on the MGI analysis, one could argue that big data is not a fad but is a revolution as real as the agricultural, industrial, and information revolutions in past centuries.

Congruent with the big data revolution is the demand for graduates with expertise in big data and analytics. Those with big data skills such as data analysis, data acquisition, data mining, and data structures are enjoying an 89.9% increase in industry demand in the last twelve months (Columbus, 2014). In a recent big data survey, 47% of respondents list finding employees with the requisite expertise as their primary concern regarding big data since overall growth in the area is expected to exceed 240% by 2017 (Henschen, 2013; Platt, 2014). Similarly, over 40% of those responsible for staffing indicate big data and analytics as their top hiring priority (Henschen, 2012). Shortages of 1.5 million managers with big data expertise are anticipated, with shortages of up to 190,000 big data scientists by 2018 (Power and Hermacinski, 2013). In fact, a data scientist is considered the “sexiest job of the 21st century” according to the title of an article in the *Harvard Business Review* (Davenport and Patil, 2012). The average salary for professionals with big data expertise exceeds $100,000 (Columbus, 2014).

A CIO roundtable panel at the International Conference on Information (ICIS) in 2011 recognized the need for graduates prepared to fill these jobs in big data and analytics. In the ICIS 2011 Panel Report, there was a specific request for MIS programs to create new curricula in business analytics and big data (Gefen et al., 2011). Although research regarding integrating data into the MIS curriculum has been published since this report, few empirical studies have been published that compare the state of IS programs since the 2011 ICIS Panel Report and the present movement, or lack of movement, to incorporating big data and analytics into IS curricula (Anderson et al., 2014; Brandon, 2015; Chiang, Goes, and Stohr, 2012; Jacobi et al., 2014; Kang, Holden, and Yu, 2015; Mahadev and Wurst, 2015; Silva et al., 2014). Assessment of this progress can provide guidance about additional needed changes in IS curricula as well as insights into how MIS programs can be best positioned to respond to future needs of the evolving job market.

The big data and analytics domain is large and a framework can be helpful in evaluating specific curricular needs. Recent research by Kang and his colleagues (2015) identified four pillars of analytics and suggested related skills for each pillar (See Figure 1). The four pillars include: 1) data preprocessing, storage, and retrieval; 2) data exploration; 3) analytical models and algorithms, and 4) data product. Other research has also identified a variety of areas related to big data (i.e. 19 big data content considerations and 10 big data skill areas) (Columbus, 2014; Gefen et al., 2011). Drawing on this framework, we identify three objectives and five research questions for this study.

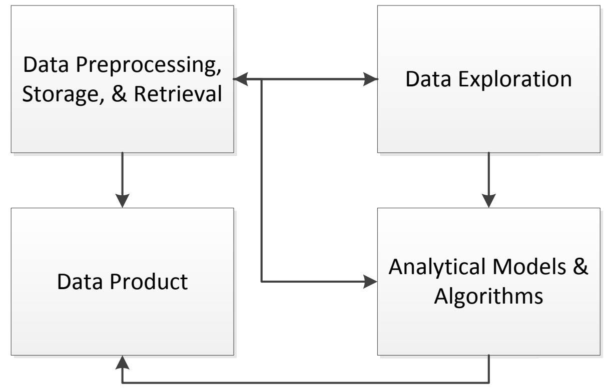

Figure 1. Skills Required by Pillars of Analytics (Kang, Holden, and Yu, 2015)

Objective 1: Using the Pillars of Analytics as a framework, what changes have taken place regarding big data/analytics curricula between 2011 and 2016?

RQ 1: What percentage of programs have added additional big data/analytics courses between 2011 and 2016?

RQ 2: What are the most common analytics offerings?

Objective 2: Do department course offerings in 2011 impact changes in analytics courses offered in 2016?

RQ 3: What impact does offering advanced database courses in 2011 have on analytics courses offered in 2016?

RQ 4: What impact does adherence to the 2010 model curriculum recommendations have on analytics courses offered in 2016?

Objective 3: Do department resources impact changes of analytics courses offered in 2016?

RQ 5: What impact do program tuition costs have on analytics courses offered in 2016?

2. LITERATURE REVIEW

2.1 Big Data/Analytics Research in IS Curriculum

In 2011, an ICIS Panel report addressed MIS curricula and found a disconnect between what academia teaches and what industry needs. The panel specifically called for additional focus and coursework on business analytics, data mining, SQL, and big data (Gefen et al., 2011). SQL was likely mentioned because from a data-centric approach, big data and analytics have their roots in the database field (Chen, Chiang, and Storey, 2012).

> Universities have been moving to address the industry gaps. IS groups have been responding especially to the opportunity of delivering academic programs that specialize in data and business analytics, to form data scientists. Such programs are proliferating fast (Goes, 2014, p. iii).

Similarly, "Colleges are rushing to develop curriculums, courses, and teaching methods to prepare students for this field" (Brandon, 2015, p. 6).

Coverage of big data requires a different approach from the database content that is traditionally included in MIS curricula. Big data is characterized by higher volume, velocity, and variety (the three Vs) of data, which are beyond the capabilities of traditional database management tools (Gupta, Goul, and Dinter, 2015). Veracity is considered by some as a fourth 'V' related to big data (Goes, 2014). Further, big data utilizes data sets differently than standard Structured Query Language (SQL). While SQL typically facilitates which data satisfies a given pattern, big data addresses questions like what patterns are related to the given data (Dhar, 2013).

Prior research has investigated integrating big data and analytics into the curriculum. For instance, (Silva et al., 2014), developed Big Data Management Systems (BDMS) learning units which include Map Reduce, NoSQL, and NewSQL. Micro-level recommendations such as in-class exercises and assignments, as well as achieving learning objectives were presented. Some vendors provide a bridge to move data between Map Reduce technologies and SQL systems (Chaudhuri, Vivek, and Narasayya, 2011).

Other studies have made recommendations regarding big data and analytics topics and course coverage. Chiang and colleagues (Chiang, Goes, and Stohr, 2012) identified three broad areas when classifying big data curriculum: 1) Analytical Skills (i.e., data mining, neural networks); 2) IT Knowledge and Skills (i.e., relational databases, ETL, OLAP, visualization); and 3) Business Knowledge (i.e., understand business issues and functional business areas). Somewhat unique to this model is a focus on business foundation knowledge such as accounting, finance, and marketing. Its assumption is that it is critical that a data scientist is immersed in the business domains where he or she works. The domain provides a specific context in which to ground analysis and interpretation of the data, and enables the data scientist to offer recommendations specific to the context.

Kang and his colleagues (2015), derived four pillars targeted at graduate IS programs (See Table 1). The four pillars of analytics are addressed in the curriculum and students work in each of the pillars as they complete an analytics track. While these pillars were designed for a graduate program, they also have broad usability when examining integration of analytics into any curriculum, including that for undergraduates. The four pillars are targeted directly on big data/analytics and do not address topics such as ethics or business foundations.

Pillars of Analytics	Skills
Data Preprocessing, Storage, and Retrieval	NoSQL, Data Modeling, Data Warehousing & Distribution/Parallel Computing
Data Exploration	Statistical Analysis & Visualization
Analytical Models & Algorithms	Machine Learning/Data Mining, Natural Language Processing, Information Retrieval
Data Product	Data and Information Organization, Knowledge Representation & Application Development

Table 1. Skills Required by Pillars of Analytics (Kang, Holden, and Yu, 2015)

A third big data/analytics outline is offered by Anderson and colleagues (Anderson et al., 2014). It focuses on a comprehensive program for undergraduate students in predictive analytics, machine learning, and data mining, and found that over 10 years, big data and analytics training is viable at the undergraduate level (Anderson et al., 2014). Although there are commonalities with Kang, Holden, and Yu's (2015) four pillars, Anderson et al.'s (2014) outline addresses additional topics outside traditional big data by including topics such as ethics and business communications.

Finally, Gupta, Goul, and Dinter (2015), provide the largest list of topics to be covered, with 18 different big data and analytics topic areas. Their research employed a multi-methodological approach including literature review, expert interviews, and surveys to identify the 18 coverage areas for undergraduate curricula. The list includes extensive business intelligence topic coverage, as well as ethical, cultural, and strategic issues.

Table 2 summarizes the prior discussion and the recommended skills required for coursework in big data and analytics. While the 2010 IS Curriculum guidelines do not specifically address analytics course offerings, other than database/SQL as part of its core, the opportunity to provide career track options to allow students to focus on a particular area such as data analytics is highlighted (Topi et al., 2010).

"As a community of scholars we would be remiss not to take full advantage of the scientific possibilities created by the availability of big data, sophisticated analytical tools, and powerful computing infrastructures" (Agarwal and Dhar, 2014, p. 447).

Research	# of Areas	Areas/Pillars/Topics
Anderson et al., 2014	Eight Areas for Big Data/Analytics	1) large data sets: create/design, access, clean, analyze, aggregate, organize, visualize; 2) Database: design, storage, query, modeling; 3) AI techniques: genetic algorithms, neural networks, machine learning, pattern matching; 4) Software and Algorithms: design, programming, testing; 5) Information retrieval: Information theory, data mining, text mining; 6) Mathematics: logic and counting, discrete structures, statistics, modeling and simulation; 7) Oral and written communication; 8) Social, ethical, and legal issues: privacy and security
Chiang, Goes, and Stohr, 2012	Three Areas for Big Data Curriculum	1) Analytical Skills (i.e., data mining, neural networks); 2) IT Knowledge and Skills (i.e., relational databases, ETL, OLAP, visualization); and 3) Business Knowledge (i.e., understand business issues and functional business areas
Gupta, Goul, and Dinter, 2015	Eighteen Topic Areas (Undergrad & Grad)	1) Intro to BI; 2) DBMS; 3) Dimensional modeling; 4) BI Infrastructure (i.e., data warehouse); 5) BI Infrastructure (i.e., dashboards); 6) Data visualization; 7) Data/Text mining; 8) EIS; 9) BI applications; 10) Business justification for BI applications; 11) BI management; 12) Strategic uses of BI; 13) Data security; 14) Ethical issues in BI; 15) Web based BI; 16) Future trends; 17) Business performance management; 18) BI and organizational issues (i.e., culture)
Kang, Holden, and Yu, 2015	Four Pillars of Analytics	1) Data Preprocessing, Storage, and Retrieval (i.e., NoSQL, Data Modeling); 2) Data Exploration (i.e., Visualization); 3) Analytical Models & Algorithms (i.e., Machine Learning, Data Mining); 4) Data Product (i.e., Application Development)

Table 2. Skills Required for Big Data and Analytics

2.2 Shortage of Analytics Expertise in Industry

With data worldwide growing between 40% and 50% per year, those with big data and analytics skills are in strong demand (Gordon, 2013; Manyika et al., 2011). Data scientists with degrees in information systems-related fields are also in top demand with serious hiring shortages expected with those who possess depth in big data and analytics (Manyika et al., 2011). A survey of 153 IT professionals found technology skills including SQL, computer languages, and web design critically important for future industry needs (Downey, McMurtrey, and Zeltmann, 2008). Further, demand for graduates with SQL knowledge also continues to grow as it continues to be a standard data access method for big data (Soat, 2014). High salaries and high demand exert upward pressure and average salaries for professionals with big data and analytics exceed $100,000 (Columbus, 2014).

The demand for graduates with expertise in big data and analytics goes well beyond MIS. "Big Data is the biggest game-changing opportunity for marketing and sales since the Internet went mainstream almost 20 years ago" (Davis et al., 1997, p. 1). He continues by arguing that companies that use big data and analytics effectively are over five percent more profitable than their peers. For instance, in marketing, databases can help develop a comprehensive picture of customers so companies can personalize and address their needs (Gordon, 2013).

Database marketing improves profitability, increases sales, improves marketing communications, and improves product development (Duval, 2013). Similarly, projections suggest there is more than $300 billion potential annual value that could be created by implementing analysis of the big data stored by the healthcare industry (Manyika et al., 2011). Wall Street investment banks and security firms are searching for analyst professionals with database skills as well (Taft, 2012).

Internet and data driven businesses are driving the demand for people with skills in predictive modeling and machine learning (Dhar, 2013). Leading demand for big data professionals includes specific skills in Python programming (96%), Linux (76%), and SQL (76%) (Columbus, 2014).

Table 3 shows a list of additional demanded skills related to big data and analytics. Currently, nearly 1 in every 20 professional careers in the United States relates to software development where employers are seeking individuals with programming languages including Python and SQL (Gallagher, 2015).

Skill	% Growth in Demand Over Previous Year
Python	96
Structured Query Language (SQL)	76
Linux	76
Data warehousing	69
Java	63

Table 3. Industry Demand Increases for Big Data Professionals (Columbus, 2014)

2.3 Research Methodology and Data Collection

As described in more detail in the next two sections, data for our analyses were gathered over three months in fall 2011 and over two months in late 2015 and early 2016. Our sample was a randomly selected set of AACSB programs at universities around the United States. Specific questions to address our research questions and objectives were created, reviewed by other faculty who were experts in MIS curricula issues, and revised appropriately. Data to answer these questions came from an examination of the universities' websites, catalogs of course descriptions, and in some cases, telephone interviews with academic advisors to uncover data not available from the online sources. Now, we describe our methods in more detail.

2.3.1 Population and Sample: The population for this research included undergraduate information systems programs at AACSB-accredited institutions within the United States. Our baseline data came from the same 118 programs, out of approximately 485 AACSB programs, which were randomly selected and used by Bell, Mills, and Fadel (2013) in their 2011 analysis. As reported in their manuscript, data were gathered over three months in Fall 2011. Consistent with Yamane's (1967) formula based on a confidence interval of 90%, a minimum of 74 programs was needed in the sample size, out of the 485 AACSB programs, to provide sufficient statistical power for the statistical analyses. Our sample size of 118 exceeds this minimum. One hundred and four programs (80%) were public and 25 were private institutions.

Programs represented geographic regions throughout the United Sates (i.e., West 21, Midwest 32, South 51, Northeast 25). Seventy-nine programs (61%) were on the quarter system, with fifty on the semester-based system. The average compliance to the IS 2010 Model Curriculum Guidelines was approximately 44%. Program names varied, including 43 named MIS, 22 IS, 21 CIS, and 41 had other names. The average annual tuition for these programs was $13,850, with annual business school budgets averaging $21,000,000.

2.3.2 Data Collection Procedures: The survey instrument (See Appendix A) was developed primarily based on the literature review presented earlier in this paper, and focused on the analytic pillars (Kang, Holden, and Yu, 2015) analytics skills (Columbus, 2014), and program clusters (Mills et al., 2012). An initial set of questions to address our research questions and objectives was prepared by the first author. Then, they were reviewed by two faculty members with a background in information systems and IS curriculum design to ensure appropriate data were collected. Minor changes were made based on their feedback, suggesting that the final set of questions meets requirements for content validity.

Baseline data for 2011 came from the Bell, Mills, and Fadel (2013) dataset, which had been initially collected over three months in Fall of 2011. The second set of data was collected over two months in Fall 2015 and Spring 2016 directly from universities' websites. Primary sources were a department's website that described its curriculum offerings and online course catalogs to provide insight into course content. We called academic advisors if critical data were not located on a department's website. As described in Bell et al. (Bell, Mills, and Fadel, 2013), wo researchers collected the 2011 set of data, and an additional researcher examined a random subset of 20 programs to ensure data were collected and interpreted correctly.

The 2016 data were collected over two months and employed the same direct survey methods employed in the 2011 data collections. The same data collection instrument was used along with one primary data collector. Follow-up for this data sample included two follow-up data collectors, including the same individual used in 2011 to help confirm the reliability of the data collected by again providing confirmation on 20 randomly selected programs. These steps provided assurance of reliability in the analyses.

3. DATA ANALYSIS AND RESULTS

3.1 Research Question 1

What percentage of programs have added big data/analytics courses? Results based on analyses of direct survey data indicate over 60% of the programs studied added at least one new big data/analytics course between 2011 and 2016. Thirty-five percent of programs added one additional course, 15% added two additional courses, around 7% added three courses, and 3% of programs added four courses. Table 4 illustrates the percentage of programs that added big data/analytics course offerings.

Course Offerings	Frequency	Percent
0	47	39.8
1	42	35.6
2	18	15.3
3	8	6.8
4	3	3.4
Total	118	100

Table 4. Frequency and Percent of IS Programs adding Analytics Courses 2011-2016

3.2 Research Question 2

What are the most common analytics offerings? For this question, mean averages of courses representing each big data/analytics pillar for all schools were calculated for 2011 and 2016. These averages were then compared, which represent the move to big data and analytics over the past four years (see Tables 5-8). Results indicate a course in big data/analytics was the most commonly added course, followed by courses in visualization, business data analysis, and business intelligence.

Pillar 1 Offerings	2011	2016	% Change
Database Management	113	114	0%
Advanced Database Management	17	19	11%
Other Database/Administration	5	9	88%

Table 5. Pillar 1 – Data Preprocessing, Storage, and Retrieval Comparison – Mean Averages of Courses

Pillar 2 Offerings	2011	2016	% Change
Visualization	1	3	300%
Business Data Analysis	9	26	289%
Business Intelligence	10	26	260%

Table 6. Pillar 2 – Data Exploration Comparison – Mean Averages of Courses

Pillar 3 Offerings	2011	2016	% Change
Data Mining	13	22	69%
Data Warehousing	7	10	43%

Table 7. Pillar 3 – Models and Data Mining Comparison – Mean Averages of Courses

Pillar 4 Offerings	2011	2016	% Change
Big Data Analytics	6	34	583%
Decision Support and Expert Systems	7	9	29%

Table 8. Pillar 4 – Product Comparison – Mean Averages of Courses

Results indicate that all pillars experienced growth in offerings from 2011 to 2016. Pillar #1 (Data Preprocessing) showed the most modest increases from 2011 to 2016, but it already had extensive coverage in 2011 because of a database management/SQL course that was commonly included in curricula. Courses in big data Analytics (Pillar #4), Visualization (Pillar #2), Business Data Analysis (Pillar #2), and Business Intelligence (Pillar #3) experienced the greatest increase as a percentage from 2011 to 2016 (see Table 9).

Big Data/Analytics Course	Percentage Increase Over 2011	Percentage Required in 2016
Big Data Analytics	583%	77%
Visualization	300%	75%
Business Data Analysis	289%	81%
Business Intelligence	260%	73%

Table 9. Most Common Analytics Offerings Added Between 2011 and 2016

3.3 Research Question 3

What impact does offering an advanced database course in 2011 have on analytics courses offered in 2016? To examine this research question, a one way between groups analysis of variance (ANOVA) was conducted using advanced database offerings from 2011 as the independent variable with the dependent variable including the number of new analytics courses offered in 2016. The independent variable included a 0 (no advanced database course in 2011) or 1 (advanced database course located in 2011). The dependent variable included a range of 0 to 4 new analytics course offerings in 2016). Assumptions of homoscedasticity were assessed with the Levene test of homogeneity of variances (Levene Statistic 0.255, df1 1, df2 116, Sig. 0.614).

There was a significant effect of departments offering advanced database courses in 2011 on new analytics course offerings in 2016 at the $p<.05$ level [$F(1, 116) = 6.219$, $p=0.014$] (See Tables 10 and 11).

New Analytics Course Offerings	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
No (0)	101	0.87	0.997	0.099	0.067	1.07
Yes (1)	17	1.53	1.068	0.259	0.98	2.08
Total	118	0.97	1.029	0.095	0.78	1.15

Table 10. 2011 Advanced Database Impact on 2016 Analytics Course Offerings

	Sum of Squares	Df	Mean Square	F
Between Groups	6.302	1	6.302	6.219**
Within Groups	117.562	116	1.013	
Total	123.864	117		
**P<.05				

Table 11. ANOVA for the Regression Equation, Database on Analytics Offerings

In order to evaluate differences between the content of introductory and advanced database courses and analytics courses, we analyzed course catalog data for the programs in our sample. We found most introductory database courses include basic SQL programming topics such as joining, grouping and subquerying. In addition, topics such as Entity Relationship Diagramming, normalization and relational modeling are generally covered in the introductory course. Once again, based on course catalog data, the advanced database course includes topics such as concurrency control, query performance, data warehousing, indexing, XML integration, and advanced SQL techniques such as window functions, triggers, derived tables, and user-defined functions. We also identified several advanced courses that provided coverage of integrating databases with other systems (e.g., CRM, ERP).

3.4 Research Question 4

What impact does adherence to the 2010 model curriculum recommendations have on analytics courses offered in 2016? To examine this research question, a chi-square of independence was performed to examine the relationship between adherence to the 2010 model curriculum recommendations (high or low) and new analytics course offerings in 2016 (high or low). Adherence to the 2010 model curriculum was assessed based on findings from Bell et al.'s (Bell et al., 2013) analysis, and new analytics course offerings in 2016 was assessed from data collected from our examination of departments' websites. The IS 2010 Model Curriculum adherence percentage used for this analysis is provided in Table 12. The relationship between these variables was not significant, X2 (1, 118 = 0.034, p=0.854).

Percentage Adherence	Adherence by Frequency	Percentage Adherence by Frequency
20%	7	5.4%
30%	12	9.9%
40%	33	27.3%
50%	36	29.8%
60%	19	15.7%
70%	8	6.6%
80%	6	5.0%
		100%

Table 12. Calculated Adherence to IS 2010 Guidelines (Bell, Mills, and Fadel, 2013)

Percentage Adherence	IS 2010 Adherence (Low/High)	
New Analytics Course Offerings	Low (0)	High (1)
No (0)	20, *43*	29, *41*
Yes (1)	27, *57*	42, *59*
Note: X2 = 0.034, df=1. Numbers in italics indicate column percentages. *P<.05		

Table 13. Results of Chi-Square Test for IS 2010 Adherence and Analytics Offerings

3.5 Research Question 5

What impact does tuition costs have on analytics courses offered in 2016? To examine this research question, a chi-square of independence was performed to examine the relationship between tuition costs (high or low) and new analytic course offerings in 2016 (high or low). The relationship between these variables was not significant, X2 (1, 113 = 0.035, p=0.557).

Percentage Adherence	Tuition Costs (Low/High)	
New Analytics Course Offerings	Low (0)	High (1)
No (0)	59, *72*	24, *77*
Yes (1)	23, *28*	7, *23*
Note: X2 = 0.035, df=1. Numbers in italics indicate column percentages. *P<.05		

Table 14. Results of Chi-Square Test for Tuition Costs and Analytics Offerings

4. DISCUSSION

Many of the component parts of data science are not new but it has become increasingly important as organizations coalesce around the idea that analytics is crucial for improved decision making and thus, improved performance (Agarwal and Dhar, 2014). It turns out that old data component parts combined with new data technologies and models have formed a new, lethal discipline – data science.

This research provides a first empirical examination regarding IS programs moving to big data and analytics, and findings confirm there is a dramatic increase from the 2011 baseline. Pillar 2 (Data Exploration) and Pillar 4 (Product) experienced the largest growth. This includes courses in visualization, business data analysis, and business data analytics, and supports prior claims that IS programs are rushing to develop curricula in this area (Brandon, 2015). At the same time, almost 40% of the IS programs did not add a big data or analytics class and 36% added only one course (see Table 4).

One explanation may be that many IS departments did not have current faculty, or were unable to hire new faculty, to teach more advanced data science classes. Another explanation is that departments could not add new courses without deleting existing courses in their IS curricula, and were unwilling or unable to make this tradeoff. Additional research is needed to understand which explanation is correct.

Still, it is difficult to understate the magnitude of change in MIS towards big data and analytics. For example, the increase in the number of business intelligence courses grew from 10 in 2011 to 26 in 2016, similar to the increase in business data analysis courses (see Table 6). Both of these courses are in Pillar 2 (Data Exploration), which also includes statistical methods. One explanation for the extraordinary growth in this pillar is that IS faculty and faculty who teach quantitative methods sometimes reside in the same department. IS programs may have found it easier to expand their course offerings in this pillar because faculty skilled in quantitative methods could more easily retool to teach business data analysis courses.

This research also finds programs with established database offerings, including an advanced database course (Pillar 1 – Data Preprocessing), were significantly more likely to add big data/analytics offerings. This seems reasonable as the initial pillar in data preprocessing logically serves as a foundation to build other data science-related offerings. The subject-matter experts teaching advanced database courses were likely among the first IS academics to recognize the growing importance of data to organizations. Concurrently, as organizations realized the benefits, demand for new employees skilled in data science grew at a rapid pace. To meet this demand, those teaching advanced database courses likely championed increased course offerings in data analytics at their universities.

Perhaps most surprising, we did not find a relationship between adherence to the IS 2010 Model Curriculum guidelines in 2011 and changes to big data/analytics offerings in 2016. Our initial predictions, however, could be argued in several directions. We had posited that programs with adherence to the curriculum guidelines would be more likely to respond to the market demand for graduates with expertise in analytics by adding additional courses because the guidelines encourage programs to offer career tracks that met the local needs of students and recruiters. Alternatively, one could argue that programs with high IS 2010 Model Curriculum adherence did not have the flexibility to add additional courses to their curricula since adherence suggests that a significant number of courses were already required to major in information systems. However, we didn't find programs with low adherence were any more likely to add new analytics courses than those with high adherence. Could it be that in times of rapid change, curriculum guidelines are less relevant than an institution's need to respond to market needs by modifying its curriculum?

All of the programs in our sample were AACSB-accredited programs. This means that all are expected to provide assurance of learning standards for their programs, within the context of curriculum management (AACSB International, 2013). One way is to demonstrate adherence to a subject-matter curriculum standard, such as the IS 2010 Model Curriculum. A parallel driver of curricula is the types of knowledge, skills, and abilities demanded by the employers who recruit a university's graduates. Given the extraordinary and rapid growth in demand for data science graduates, an IS department's decision to add new data science courses may have taken precedence over an overarching curriculum assessment. For example, one could envision a scenario where the recruiting marketplace responded so enthusiastically after an IS department added a single analytics course, that the department felt compelled to add additional courses as expeditiously as possible in order to prepare its graduates to meet an unexpected and growing need. Thus, the driver behind curriculum change and the addition of new analytics and business intelligence courses was to respond to market demand as rapidly as possible, rather than a more deliberate assessment of an overarching curricula. Future research is needed to determine whether this explanation is correct.

We also need to acknowledge limitations to this research. It was beyond the scope of this study to identify current industry practice and needs in order to know whether a given curriculum truly meets industry's needs. Further, data science is a multi-disciplinary area that requires a diverse skillset. IS programs may not be able to cover the entire panoply of knowledge and skills that a data scientist needs. Future research could conduct a comprehensive analysis of industry needs, and map those needs to IS curricula, as well as other referent disciplines such as statistics or computer science.

Certainly there have been shifts in MIS topic areas before. We observed one or two additional courses in e-commerce in some programs around 2001, and security saw similar growth around 2005, but this area was confined to a smaller number of MIS programs. We are not aware of any published research about IS curricula that describes as monumental a change as the move to data analytics, as reflected in the quantity of courses, the breadth of courses, and the speed at which they have been implemented. Our findings may also be helpful to IS leadership responsible for updating the IS Model Curriculum to consider when making future changes.

The IS 2010 Model Curriculum guidelines do provide an opportunity for programs to offer customized career tracks based on local area demands. Data from this research provide a foundation for programs that want to offer a career track in data science. Based on our findings, Table 15 would represent a potential data scientist career path that includes all four Pillars (Figure 2). These courses were selected from a larger set of classes, based on the data we collected about IS curricula in 2016.

Core IS Courses: • Foundations of IS • IS Strategy • Systems Analysis & Design • IT Infrastructure • IT Project Management • Data and Information Management (Pillar 1 – Data Preprocessing)
Elective IS Courses: • Advanced Database Management (Pillar 1 – Data Preprocessing) • Visualization (Pillar 2 – Data Exploration) • Business Intelligence (Pillar 2 – Data Exploration) • Data Mining (Pillar 3 – Analytical Models) • Big Data Analytics (Pillar 4 – Data Product) • Programming with Python • Statistical Methods

Table 15. Sample Data Science IS Career Track

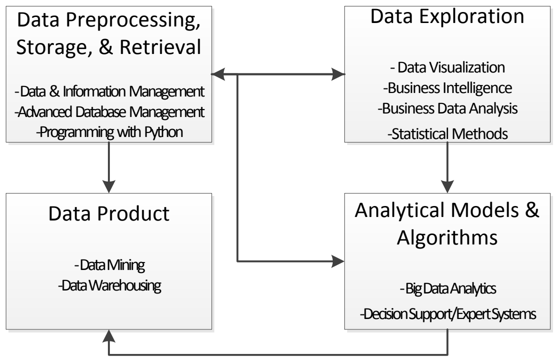

Figure 2. Skills Required by Pillar of Analytics based on Current Study Data (Kang, Holden, and Yu, 2015)

In sum, this paper provides important data to both industry and MIS program leaders making curriculum decisions. Given that the formal term 'data scientist' had not been officially coined until 2008, the results of this study indicate IS programs are moving quickly to fill industry needs and anticipated shortages in this high-demand, high-paying area. The data show many IS programs have responded to industry needs by adding courses in the area of big data and analytics.

Concurrently, IS programs may also want to evaluate the course additions within the context of conducting an overarching curriculum assessment. Does the IS program want to offer its students a curriculum that covers the breadth of IS topics as described in the IS Model Curriculum, or is a program that covers an area (e.g., big data and analytics) in depth the better course of action? The breadth versus depth question will continue to be relevant in the future if IS programs want to be positioned to respond to future needs of an evolving job market.

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