

INFORMATION SYSTEMS EDUCATION JOURNAL

In this issue:

- 4. Business Analytics in Practice and in Education: A Competency-based Perspective**
Stanislav Mamonov, Montclair State University
Ram Misra, Montclair State University
Rashmi Jain, Montclair State University
- 14. Learning Styles, Online Content Usage and Exam Performance in a Mixed-Format Introductory Computer Information Systems Course**
Guido Lang, Quinnipiac University
Stephen D. O'Connell, CUNY Graduate School and University Center
- 23. Evaluating Business Intelligence / Business Analytics Software for Use in the Information Systems Curriculum**
Gary Alan Davis, Robert Morris University
Charles R. Woratschek, Robert Morris University
- 30. T0: Discrete Math and Programming Logic Topics as a Hybrid Alternative to CS0**
Nancy L. Martin, Southern Illinois University
- 45. A Proposed Concentration Curriculum Design for Big Data Analytics for Information Systems Students**
John C. Molluzzo, Pace University
James P. Lawler, Pace University
- 58. A Design Quality Learning Unit in OO Modeling Bridging the Engineer and the Artist**
Leslie J. Waguespack, Bentley University

The **Information Systems Education Journal** (ISEDJ) is a double-blind peer-reviewed academic journal published by **EDSIG**, the Education Special Interest Group of AITP, the Association of Information Technology Professionals (Chicago, Illinois). Publishing frequency is six times per year. The first year of publication is 2003.

ISEDJ is published online (<http://isedj.org>). Our sister publication, the Proceedings of EDSIG (<http://www.edsigcon.org>) features all papers, panels, workshops, and presentations from the conference.

The journal acceptance review process involves a minimum of three double-blind peer reviews, where both the reviewer is not aware of the identities of the authors and the authors are not aware of the identities of the reviewers. The initial reviews happen before the conference. At that point papers are divided into award papers (top 15%), other journal papers (top 30%), unsettled papers, and non-journal papers. The unsettled papers are subjected to a second round of blind peer review to establish whether they will be accepted to the journal or not. Those papers that are deemed of sufficient quality are accepted for publication in the ISEDJ journal. Currently the target acceptance rate for the journal is under 40%.

Information Systems Education Journal is pleased to be listed in the 1st Edition of Cabell's Directory of Publishing Opportunities in Educational Technology and Library Science, in both the electronic and printed editions. Questions should be addressed to the editor at editor@isedj.org or the publisher at publisher@isedj.org.

2015 AITP Education Special Interest Group (EDSIG) Board of Directors

Scott Hunsinger
Appalachian State Univ
President

Jeffry Babb
West Texas A&M
Vice President

Wendy Ceccucci
Quinnipiac University
President – 2013-2014

Eric Breimer
Siena College
Director

Nita Brooks
Middle Tennessee State Univ
Director

Tom Janicki
U North Carolina Wilmington
Director

Muhammed Miah
Southern Univ New Orleans
Director

James Pomykalski
Susquehanna University
Director

Anthony Serapiglia
St. Vincent College
Director

Leslie J. Waguespack Jr
Bentley University
Director

Peter Wu
Robert Morris University
Director

Lee Freeman
Univ. of Michigan - Dearborn
JISE Editor

Copyright © 2015 by the Education Special Interest Group (EDSIG) of the Association of Information Technology Professionals (AITP). Permission to make digital or hard copies of all or part of this journal for personal or classroom use is granted without fee provided that the copies are not made or distributed for profit or commercial use. All copies must bear this notice and full citation. Permission from the Editor is required to post to servers, redistribute to lists, or utilize in a for-profit or commercial use. Permission requests should be sent to Nita Brooks, Editor, editor@isedj.org.

INFORMATION SYSTEMS EDUCATION JOURNAL

Editors

Nita Brooks
Senior Editor
Middle Tennessee
State University

Thomas Janicki
Publisher
University of North Carolina
Wilmington

Donald Colton
Emeritus Editor
Brigham Young University
Hawaii

Jeffry Babb
Associate Editor
West Texas A&M
University

Wendy Ceccucci
Associate Editor
Quinnipiac University

Melinda Korzaan
Associate Editor
Middle Tennessee
State University

George Nezelek
Associate Editor
Univ of North Carolina Wilmington

Samuel Sambasivam
Associate Editor
Azusa Pacific University

Anthony Serapiglia
Teaching Cases Co-Editor
St. Vincent College

Lawrence Cameron
Teaching Cases Co-Editor
University of Montana

ISEDJ Editorial Board

Samuel Abraham
Siena Heights University

James Lawler
Pace University

Alan Peslak
Penn State University

Teko Jan Bekkering
Northeastern State University

Michelle Louch
Duquesne University

Bruce Saulnier
Quinnipiac University

Gerald DeHondt II

Cynthia Martincic
Saint Vincent College

Li-Jen Shannon
Sam Houston State University

Janet Helwig
Dominican University

Muhammed Miah
Southern Univ at New Orleans

Karthikeyan Umapathy
University of North Florida

Scott Hunsinger
Appalachian State University

Marianne Murphy
North Carolina Central University

Bruce White
Quinnipiac University

Mark Jones
Lock Haven University

Peter Y. Wu
Robert Morris University.

A Proposed Concentration Curriculum Design for Big Data Analytics for Information Systems Students

John C. Molluzzo
jmolluzzo@pace.edu

James P. Lawler
jlawler@pace.edu

Pace University
One Pace Plaza
New York, New York 10038

Abstract

Big Data is becoming a critical component of the Information Systems curriculum. Educators are enhancing gradually the concentration curriculum for Big Data in schools of computer science and information systems. This paper proposes a creative curriculum design for Big Data Analytics for a program at a major metropolitan university. The design emphasizes expanded learning of business, mathematical and statistical, and presentation skills, in projects of teams, in addition to skills in technology. This paper will be beneficial to educators considering improvement of the curriculum for Big Data Analytics and to students desiring a more contemporary program.

Keywords: analytics, big data, computing curricula, data mining, data science, privacy, security.

1. BACKGROUND AND DEFINITION

"Data is the New Oil" (Smolan and Erwitte, 2012).

Big Data is defined as "bigger and bigger and bigger" (Aiden, & Michel, 2013) aggregates of data that challenge business firms in analyzing business benefit with common software. Big Data dimensions are defined in a diverse variety of structured data, such as traditional transaction data, and non-structured data, such as mobile sensor and social media networking data; in a velocity as to rapid sensitivity to real time timeliness of the data; in a veracity as to the purity of sizable volume; and in sheer streaming volume (Ohlhorst, 2013). Big Data is essentially a data management paradigm shift (Borkovich, & Noah, 2013). Big Data is estimated to be in dozens of terabytes to

multiples of petabytes (IBM, 2014), growing 50% each year and 100% every 2 years in business firms (Lohr, 2012); and is estimated to be further impacted by increased information from the "internet of things" (Morozov, 2014), such as consumer wearables (Minsker, 2014a). Firms in the retail industry, such as Walmart, store 2.5 petabytes or 1 quadrillion bytes of data (McAfee, & Brynjolfsson, 2012). The storing of data however is less important than the business benefit to be acquired from the analysis of the data, in cost control, decision improvement and design improvements in processes, products and services (Davenport, 2014), especially from the cross-fertilization of customer social networking and transaction data streaming into firms (Brustein, 2014). The accessibility of such data is apparently a "big deal" (eWeek, 2013), as firms exploit the potential of data analytics in

this perceived revolution of technology (Freeland, 2012).

The benefits of Big Data Analytics (henceforth referred to as BDA) are cited frequently in firms (IBM, 2014). Amazon is analyzing data for competitive customer micro-segmentation of products to customize its products and services; Google is analyzing messaging to improve its services (Rosenblatt, 2014); and Tesco and Walmart are analyzing demographics to lower inventory pricing of products and services at their stores. Twitter is analyzing hashtags for more patterns of potential sales from subject trends. Firms are clearly interested in BDA to optimize the outcomes of processes, products and services. Even the government and the health industry (Kim, Trimi, & Chung, 2014) are commencing initiatives in efficiency, decision improvement and cost control from BDA to optimize the outcomes of processes and services (Liyakasa, 2013). Though firms may be storing increased data without increased insight (Minsker, 2014b), the potential of BDA as a profitable attribute, beyond the benefits of Business Intelligence and Operations Research, is evident in the literature (King, 2014). This potential invites consideration of BDA as a differential feature of learning in schools of computer science and information systems.

Graduates from schools of computer science and information systems can contribute to the field of data analytics if the curricula of the schools include BDA. Though firms are investing in BDA, they do not have enough data scientists or specialists (May, 2013) for extracting the potential of their data (McCafferty, 2013). Graduates can contribute to the field if they have analytical business skills (Janicki, Cummings, & Kline, 2013) and content domain expertise skills (Poremba, 2013) to critically evaluate the business (Pratt, 2013) of Big Data. They can contribute to this evaluation if they have computational mathematical and statistical skills (Hulme, 2013), can interpret in a high performance environment the complex event significances of structured and non-structured data, and evaluate potential problem solutions or proposed strategies (Pratt, 2013). They can contribute further if they have privacy and security sensitivity skills in standards for Big Data housed by organizations, especially given intrusion issues as discussed in the literature (Lohr, 2013, Sengupta, 2013, & Angwin, 2014). Moreover, they can contribute notably to the field if they have persuasive presentation skills

(Miller, 2013), as individual contributors or members of teams, in proposing solutions and strategies; and they can contribute powerfully if they have skills in visualization (Rao, & Halter, 2013). These skills are beyond the data base analysis, design and development skills in technology (King, 2013). Though few graduates, or even practitioners in industry (MacSweeney, 2013a), have all of these skills to be data scientists, a creative curriculum design in Data Science may improve the breadth of ensemble learning for students currently enrolled in schools of computer science and information systems.

2. FOCUS OF PAPER

"The Big Data [R]evolution holds the promise of empowering all of us with knowledge" (Smolan and Erwit, 2012).

The proposed concentration of Data Science at Pace University is the focus of this paper. The focus is apt, as firms desire BDA personnel but do not have enough expertise for initiatives on projects (Davenport, 2014). Many firms have a BDA expertise gap (Olavsrud, 2014), despite the hype of pundits. The literature indicates that industry needs 140.0 – 190.0 thousand BDA professionals if not data scientists in 2014 (Manyika, Chui, Brown, Bughin, Dobbs, Roxburgh, & Byers, 2011) and even a high of 4.4 million scientists in 2015 (IBM, 2014). Even though a concentration of Data Science is not enough for an immediate solution, the convergence is current to the expectations of industry and organizations, as they initiate investment in Big Data strategies (Messmer, 2014). The focus of this paper on the Data Science curriculum will benefit educators and students desiring a foundation for an immediately marketable program.

3. CONCENTRATION METHODOLOGY – DATA SCIENCE

"Having the data is only the beginning" (Smolan and Erwit, 2012).

Pace University is anticipating beginning a concentration in Data Science in 2015 with the offering of the Concepts of Big Data Analytics course. The concentration covers descriptive, predictive and prescriptive analytics (Camm, Cochran, Fry, Ohlmann, Anderson, Sweeney, & Williams, 2015) for data-driven decision making. The concentration is designed for undergraduate

students to learn business, mathematical and statistical, presentation, team-playing and high-level technology skills. In the concentration, projects are assigned to incubating pseudo data scientist teams (O'Neil, & Schutt, 2014) consisting of different skilled students (Schmerken, 2013) of 3–5 individuals. The projects are focused on the design of processes, products or services in a discrete industry, such as energy, entertainment, finance, health and life sciences, or retail. The projects are to be focused on BDA problems in the industries and are to be furnished with data sets of a massive scale from non-proprietary Web sites and systems, such as www.data.gov, www.enigma.io (Singer, 2014) and www.openwebanalytics.com. The projects are to include internship and mentoring of the student teams from a few firms in the industry that are partnered with the school and even have data analytics employment positions (ITBusinessEdge, 2014). In 2016–2017 a few boutique data scientist firms may be partnered with the school. Technologies in the concentration include, but are not limited to, Apache, Hadoop, MapReduce, NLP for text, NoSQL, Python tools (Knorr, 2013) and SAS tools. The concentration in Data Science is planned to begin in 2016–2017 after the Concepts of Big Data Analytics course, by expanded learning of mathematical, statistical and technology skills that will involve other faculty (King, 2013) in the school. Few schools of computer science and information systems have curriculum design initiatives in Data Science (MacSweeney, 2013b) as envisioned in this paper.

The generic learning objectives of the Data Science concentration are defined below:

- Analyze a business process, product or service for experimental improvement in an organization that can benefit by BDA;
- Collaboratively design a discovery and exploratory method for interpreting the customer data domain dynamics of the process, product or service that include structured and unstructured data sources;
- Collaboratively develop a conceptual data business model for the process, product or service problem and for the solution, infused by intelligence learned in the discovery and exploratory process and by leveraging of a BDA tool(s), integrating a data service process prototype scenario(s) – *what can the firm do*

better now with the information that it could not do before it had it? (Provost, & Fawcett, 2013);

- Collaboratively develop a governance plan for the new product or service or a process solution for the firm, informed by customer data privacy rights and security sensitivity standards; and
- Formulate an organizational production plan for integrating the data sources, systems and technologies for the proposed process, product or service solution and for integrating BDA as an overall business strategy.

The proposed courses in the concentration are 3 credits. The outcomes of the concentration are in analytical business skills, creative problem-solving skills, Big Data modeling skills, fundamental mathematical and statistical skills, and presentation and team-playing skills, and also privacy and security sensitivity skills. The goal of the concentration is for its graduates to be business data scientists, not mere scientist technologists. The curriculum is a foundation from which there may be employment postings of BDA specialties for the students upon graduation from the university.

Pending approval by an internal curriculum committee of the school, the concentration of Data Science will begin in fall 2015 with the offering of Concepts of Big Data Analytics, as discussed in this paper. The plan is to rollout the full concentration during 2015–2017 with the following courses.

Concept Courses

- Concepts of Big Data Analytics, a course on critical Big Data modeling of a process, product or service in industry;
- Big Data Maturity Model, a conceptual course on benchmarking of best Big Data organizational practices in industry; and
- Customer Relationship Management (CRM) and Big Data, a conceptual course integrating BDA and household priority relationship strategy in industry.

Domain Courses

- Big Data Analytics in Energy, a domain course integrating BDA projects for decision-making in the energy industry;
- Big Data Analytics in Entertainment, a domain course integrating BDA projects for decision-

- making in the entertainment and sports industries;
- Big Data Analytics in the Financial Industry, a domain course integrating BDA projects for decision-making in the international financial services industry;
- Big Data Analytics in Health and Life Sciences, a domain course integrating BDA projects for decision-making in the health and life sciences industry, including ObamaCare initiatives; and
- Big Data Analytics in Retail Industries, a domain course integrating BDA projects for decision-making in the retail industries.

Enabling Courses

- Big Data Ethical Framework, an integrative course on BDA privacy, regulatory and security standards governing analytics professionals in industries and organizations; and
- Big Data Foundation Technology, an integrative course on required BDA high performance infrastructure platform and storage technologies and tools.

The concentration of Data Science is depicted in Figure 1. The concentration is fulfilled in the three conceptual courses, three of the five domain courses, and the two enabling courses of the plan. The concentration is currently designed for the undergraduate students of the school but may be expanded in 2017 for graduate students of the School and of the School of Business of the university.

Table 1 lists courses that can give the student requisite skills in business, mathematics, statistics, and presentation, team-playing and high-level technology. The descriptions are fairly generic and reflect existing courses in most institutions that have a business major.

4. COURSE MODEL – BIG DATA ANALYTICS

“ ... Big Data is much more than big data” (Smolan and Erwit, 2012).

The field of data science or data analytics is relatively new, with few consistencies in the content or names of introductory courses.

During January-February, 2014, a scan of the Internet disclosed the following names for introductory courses:

- Advanced Big Data Analytics
- Analytics and Decision Analysis
- Applied Data Science

- Big Data Analytics
- Business Analytics
- Business Intelligence and Analytics
- Data Analytics
- Data Analytics for Information Systems
- Data and Decision Analytics
- Data Warehousing and Analytics
- Elements of Data Analysis
- Introduction to Business Analytics
- Introduction to Data Analytics
- Introduction to Data Science
- Large-scale Data Analysis

For this paper, the Concepts of Big Data Analytics course is outlined in Table 2 of the Appendix.

Table 2 contains five columns corresponding to the online syllabi of five university introductory Data Science or Analytics courses. Over the period of February – March 2014, the authors reviewed the online syllabi of 21 introductory courses that contained Data Analytics or Data Science in their titles, all from Tier I and Tier II universities. The courses represented in Table 2 are a representative sample of the 21 courses. The five columns can be used to compare the Concepts of Big Data Analytics course of this paper to those at these other universities. Note that the omission of a checkmark does not mean the topic is not covered in that course. The checkmarks indicate what was available on the Web sites of the universities. Table 2 does not name the universities corresponding to the five columns, in order to avoid any criticism of the universities - table is for comparison only.

The Concepts of Big Data Analytics course emphasizes the concepts behind modern Data Science. The course is conceptual in the sense that the principles behind Data Science are emphasized rather than the tools with which to implement them. Therefore, topics such as R and Python programming, Hadoop, MapReduce, and so on are not covered to any extent in this course. Instead, they are covered, as they are needed in the domain courses to solve industry-specific problems. Some topics in the course require knowledge of probability and statistics. Therefore, the basic statistics course required of all computing majors is a prerequisite for this course. Because the course has no programming requirements, it is accessible to any student in the university who has the statistics prerequisite, which thus includes all business majors in the university.

The course emphasizes the strategic value of data and the use of Data Science teams in an organization, and the use of data-driven decision-making. It introduces students to data-analytic thinking and Data Science principles to facilitate communication between business stakeholders and the Data Science teams. The course also discusses the limitations and pitfalls (e.g., overfitting) of Data Science and the necessity of human involvement in choosing the right data and evaluating the processes and results of the Data Science projects. The ultimate goal of this course is to enable students to participate in the development and proper evaluation of a Data Analytics solution to a business problem.

The text will be Provost, F., & Fawcett, T. (2013), *Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking*. Supporting texts will be Davenport, T.H. (2014), *Big Data at Work: Dispelling the Myths, Uncovering the Opportunities*. Alternately the following can be used as the text: Davenport, T.H., & Harris, J.G. (2007), *Competing on Analytics: The New Science of Winning*. The text will be supplemented by Analysis INFORMS Magazine.

The course will also discuss in detail several recent case studies of the application of BDA to real business situations. There are many online resources to obtain such cases, (e.g., BDA sites of IBM [2014] and HP Vertica [2014])

5. IMPLICATIONS

"Big Data started as a series of small waves but is morphing into the greatest tsunami of information that humans have ever seen" (Smolan and Erwit, 2012).

The terms "Big Data", "Data Science", "Data Analytics" are so ubiquitous in the practitioner press that it seems that they are just the next hyped fad that will fade into oblivion in a few years. However, with the ability to process and store the many kinds of data collected by firms and organizations, and the need to use these data to strategic advantage, the field of Data Science will not disappear soon. Several studies, such as Brynjolfsson, Hitt, and Kim (2011), and Tambe (2014), have shown that the more data-driven a firm, the more successful is the firm. Therefore, more and more organizations will be hiring data scientists to take advantage of their ever-growing store of data. There is, however, a

problem – our universities are not keeping up with the demand.

There will be a shortage of talent necessary for organizations to take advantage of big data. By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions. (Manyika, et al, 2011).

Therefore, it is important for universities to begin developing data scientists who have the requisite technical skills, and the business and content domain knowledge to leverage the data that organizations are now accumulating for advantage (Gillespie, 2014). The program in Data Science proposed in this paper helps to fill this need.

6. LIMITATIONS AND OPPORTUNITIES

The concentration of Data Science and the course on Big Data Analytics are beginning as a program in fall 2015, but evaluation of the impact of the initial program on the students may not be finished until fall 2016.

The curriculum for Data Science with Big Data Analytics is not clearly defined in the literature (Dietrich, Newton, & Corley, 2013), and the field is immature in instruction. Within the next year, the authors plan to survey instructors of introductory Data Analytics and Data Science courses with a view towards determining which topics are essential for such courses, and which topics are less so. The authors hope that this future research will help create a common core of topics for an introductory course in Data Analytics/Data Science.

The curriculum design in this paper furnishes important input to instructors in schools of computer science and information systems who want to have an initial program in tandem with trends. The literature indicates BDA as a desirable norm in organizations (Ohlhorst, 2013), an opportunity for the response of schools of computer science and information systems. The model of this paper provides a first step.

7. CONCLUSION

This paper posits a curriculum design of Big Data Analytics in the proposed concentration of Data Science at Pace University. The design includes a discovery and exploratory method of critical Big Data modeling and the improvement of a process, product or service in industry. The design provides for inclusion of an organizational plan for process, product or service solutions, and a production strategy integrating non-traditional and traditional technologies and BDA tools. The design further provides privacy rights and security sensitivity standards. The design is ideal as firms and organizations pursue BDA projects. Few organizations have the full prerequisite skills for BDA projects and strategies. Throughout this paper, the design of BDA proposes the relevance of business, mathematical and statistical, and presentation and team-playing skills, augmenting prerequisite skills in the traditional data base management technologies and in the new non-traditional BDA tools. Overall, this paper provides a beneficial proposal to instructors desiring to initiate BDA and Data Science programs to be in tandem with industrial and organizational trends, and to undergraduate students intending to be in tandem with technological trends.

8. REFERENCES

- Aiden, E., & Michel, J-B. (2013). *Uncharted: Big data as a lens on human culture*. New York, New York: Riverhead Books, 11.
- Angwin, J. (2014). Has privacy become a luxury good? *The New York Times*, March 4, 25.
- Borkovich, D.J., & Noah, P.D. (2013). Big data in the information age: Exploring the intellectual foundation of communication theory. *Proceedings of the Information Systems Educators Conference (ISECON)*, 30(2550), 2.
- Brynjolfsson, E., Hitt, L., and Kim, H.H. (2011). Strength in numbers: How does data-driven decision making affect firm performance? Retrieved May 7, 2014 from <http://ssrn.com/abstract=1819486>.
- Brustein, J. (2014). Data analysis. *Bloomberg Business Week*, March 3, 70.
- Camm, J.D., Cochran, J.J., Fry, M.J., Ohlmann, J.W., Anderson, D.R., Sweeney, D.J., & Williams, T.A. (2015). *Essentials of business analytics*. Stamford, Connecticut: Cengage Learning, 5, 6.
- Davenport, T.H. (2014). *Big data at work: Dispelling the myths, uncovering the opportunities*. Boston, Massachusetts: Harvard Business School Publishing Corporation, 6, 22.
- Davenport, T.H., & Harris, J.G. (2007). *Competing on analytics: The new science of winning*. Boston, Massachusetts: Harvard Business School Publishing Corporation.
- Dietrich, D., Newton, P., & Corley, K. (2013). Big data in the information technology / information systems / computer science curriculum. *Proceedings of the Information Systems Educators Conference (ISECON)*, San Antonio, Texas, November, 1-2.
- Freeland, C. (2012). In big data, potential for big division. *The New York Times*, January 12, 1-3.
- Gillespie, S. (2014). Who is afraid of big data? What big data can do for financial organizations and how to prepare for it. *Wall Street & Technology*, April 22, 1-3.
- Hulme, G.V. (2013). Start class: How crunching numbers can drive decisions. *CSO*, May, 14.
- HP Vertica (2014) Retrieved May 8, 2014 from <http://www.vertica.com/customers/case-studies/>.
- IBM (2014). Retrieved May 8, 2014 from <http://www.ibm.com/big-data/us/en/big-data-and-analytics/case-studies.html>.
- Janicki, T.N., Cummings, J., & Kline, D. (2013). Information technology job skill needs and implications for information technology course content. *Proceedings of the Information Systems Educators Conference (ISECON)*, 30(2504), 8.
- Kim, G-H, Trimi, S., & Chung, J. (2014). Big-data applications in the government sector. *Communications of the ACM*, 57(3), 78-85.
- King, J. (2013). Spring training for business intelligence experts: It is a whole new ballgame for traditional data analysts, as training focuses on deep knowledge of

- statistics and computer science. *Computerworld*, May 6, 29, 31.
- King, J. (2014). A reinvention convention: Premier 100 snapshots. *Computerworld*, February 24, 16.
- Knorr, E. (2013). The big picture for big data. *Infoworld: Modernizing Enterprise Information Technology*, Winter, 4-5.
- Liyakasa, K. (2013). Executive demand for data analysis grows. *Customer Relationship Management*, June, 20-21.
- Lohr, S. (2012). The age of big data. *The New York Times: Sunday Review*, February 11, 2.
- Lohr, S. (2013). Big data is opening doors, but maybe too many. *The Sunday New York Times: Sunday Business*, March 24, 3.
- Lutz, M., & Ascher, D. (2013). *Learning Python*. Sebastopol, California: O'Reilly Media, Inc.
- Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A.H. (2011). Big data: The next frontier for innovation, competition, and productivity. *McKinsey Global Institute White Paper*, May, 1.
- May, T. (2013). Stalking the elusive data scientist. *Computerworld*, May 6, 14.
- McAfee, A., & Brynjolfsson, E. (2012). Big data: The management revolution. *Harvard Business Review*, October, 1-5.
- McCafferty, D. (2013). Business must address big data knowledge gaps. *Baseline*, November 13, 2.
- MacSweeney, G. (2013a). Banks face big data and information technology talent shortage. *Wall Street & Technology*, September 19, 1-4.
- MacSweeney, G. (2013b). Good luck finding a data scientist. *Wall Street & Technology*, October 31, 1-3.
- Messmer, E. (2014). Big data: 64% of organizations looking at big data projects. *CIO*, April, 7-8.
- Miller, C.C. (2013). The numbers of our lives: Big data, big money, big skill set required. Universities are on it. *The Sunday New York Times: Education Life*, April 14, 18-19.
- Minsker, M. (2014a). Wearables will be a marketing winner. *Customer Relationship Management*, April, 14.
- Minisker, M. (2014b). Thirteen digital marketing myths debunked. *Customer Relationship Management*, April, 23.
- Morozov, E. (2014). Silicon Valley is turning our lives into an asset class. *Financial Times*, March 14, 10.
- O'Neil, C., & Schutt, R. (2014). *Doing data science: Straight talk from the front line*. Sebastopol, California: O'Reilly Media, Inc., xv-xvi, 10.
- Ohlhorst, F.J. (2013). *Big data analytics: Turning big data into big money*. Hoboken, New Jersey: John Wiley & Sons, Inc., 3,113.
- Olavsrud, T.(2014). Big data: How to close the big data skills gap by training your information technology staff, *CIO*, April, 2
- Poremba, S. (2013). The right skills for big data jobs. *Forbes*, December 4, 2.
- Pratt, M.K. (2013). From crunch to hunch: Chief information officers must teach data scientists to solve real business problems, not just play with data. *CIO*, December 1, 16, 18.
- Provost, F., & Fawcett, T. (2013). *Data science for business: What you need to know about data mining and data-analytic thinking*. Sebastopol, California: O'Reilly Media, Inc.
- Rao, A.S., & Halter, O. (2013). How to build a big data team in five steps. *Baseline*, May 29, 1-2.
- Rosenblatt, J. (2014). Is Google too big to sue? *Bloomberg Business Week*, March 6, 38-39.
- Schmerken, I (2013). Welcome to the new quants: Data scientists. *Advanced Trading*, May 17, 1-4.
- Sengupta, S. (2013). Web privacy becomes a business imperative. *The New York Times: Business Day*, March 4, B1, B8.

- Singer, N. (2014). A harvest of company details, all in one basket. *The New York Times, Business*, March 16, p. 3.
- Smolan, R., & Erwitte, J. (2012). The human face of big data. Sausalito, California: Against All Odds Productions, 14,20,21,77, 134,161.
- Tambe, P. (2014). Big data investment, skills and firm value. Working Paper. Retrieved May 7, 2014 from [http://www.datascienceassn.org/sites/default/files/Big Data Investment, Skills, and Firm Value.pdf](http://www.datascienceassn.org/sites/default/files/Big%20Data%20Investment,%20Skills,%20and%20Firm%20Value.pdf).
- (2013). Big data becoming a big deal. *eWeek*, May 23, 12.
- (2014). Big data: What is big data? *IBM White Paper*, March 7, 1-2.
- (2014). A big market for big data jobs. *ITBusinessEdge*, March 7, 2.

Editor's Note:

This paper was selected for inclusion in the journal as an ISECON 2014 Distinguished Paper. The acceptance rate is typically 7% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2014.

APPENDIX

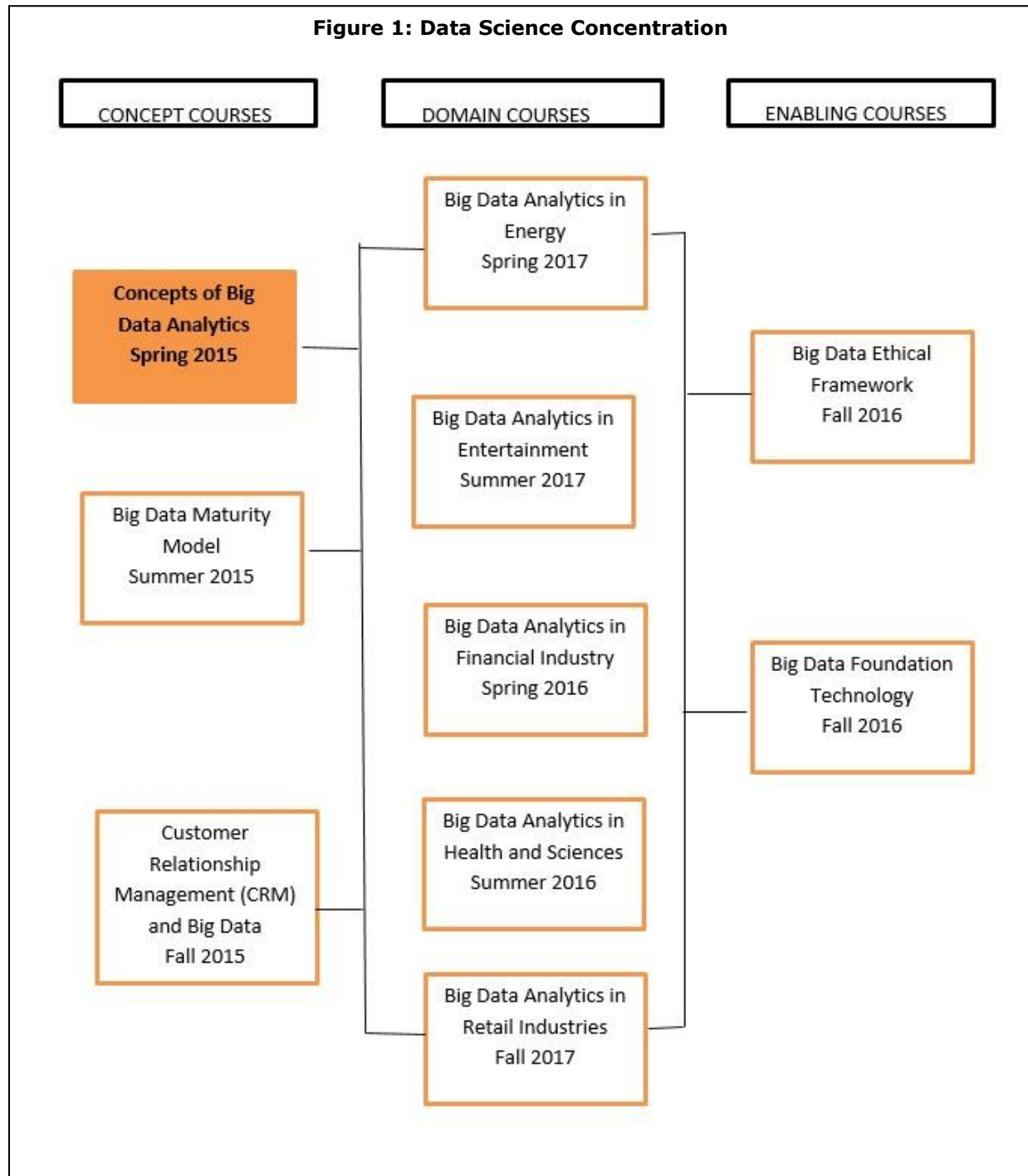


Table 1 - Possible Support Courses

Course	Description
Contemporary Business Practice	The functions of business and their interrelationships. Students work in teams to run simulated companies. Development of business writing and speaking, presentation, and data analysis skills are emphasized.
Calculus I	Limits, continuity, derivatives of algebraic, exponential and logarithmic functions, optimization problems, introduction to integral calculus, the fundamental theorem of integral calculus. Business and economic applications are stressed throughout.
Probability and Statistics	Random processes; finite sample spaces, probability models, independent events, and conditional probability. Bayes' theorem, random variables, mathematical expectation; statistical applications of probability, introduction to sampling theory, confidence intervals and hypothesis testing.
Public Speaking	The mechanics of writing and presenting one's own material. This includes outlining, addressing varied audiences, styles, and appropriate techniques of delivery, as well as the use of technology to enhance one's presentation.
Introduction to Computer Systems	The basic components of a computer, how they are organized, and how they work together under the control of an operating system. Students examine theoretical concepts underlying hardware functions, troubleshooting and preventative maintenance techniques, safety precautions, system procurement, and upgrades, and discuss networking and software as it pertains to hardware functionality.
Financial Accounting	Accounting's role in satisfying society's needs for information and its function in business, government, and the non-profit sector. Students learn from a user-oriented perspective about the accounting cycle, the nature of financial statements and the process for preparing them, and the use of accounting information as a basis for decision making.
Managerial Accounting	A study of the fundamental managerial accounting concepts and techniques that aid in management decision-making, performance evaluation, planning and controlling operations. The emphasis is on the use of accounting data as a management tool rather than on the techniques of data accumulation. The course includes such topics as cost behavior patterns, budgeting and cost-volume-profit relationships. Quantitative methods applicable to managerial accounting are studied.
Managerial and Organizational Concepts	This course examines basic managerial functions of planning, organizing, motivating, leading, and controlling. Emphasis is also given to the behavior of individual and groups within organizations.
Principles of Marketing	This course examines marketing's place in the firm and in society. Considered and analyzed are marketing research and strategies for product development, pricing, physical distribution and promotion, including personal selling, advertising, sales promotion and public relations.
Microeconomics	Theory of demand, production and costs, allocation of resources, product and factor pricing, income distribution, market failure, international economics, and comparative economic systems.
Macroeconomics	National income determination, money and banking, business cycles and economic fluctuations, monetary and fiscal policy, economic growth, and current microeconomic issues.

Table 2 - Syllabus for Concepts of Big Data Analytics						
Week	Topic	Schools				
		A	B	C	D	E
1	Data-Analytic Thinking					
	Data Science and Data-Driven Decision Making	X	X	X	X	X
	Data as a Strategic Asset Executive Firm Mentor Presentation	X	X	X	X	X
	Data-Analytic Thinking	X	X	X	X	X
2	Data Science Solutions to Business Problems					
	The Data Mining Process	X	X	X		X
	Other Analytics Techniques	X	X	X		
3	Predictive Modeling					
	Models		X	X	X	X
	Supervised Segmentation		X	X	X	X
	Visualizing Segmentations		X	X	X	X
	Trees		X	X	X	X
	Probability Estimation					
4	Model Fitting					
	Classification Using Mathematical Functions		X		X	X
	Linear Discriminant Function	X				
	Regression		X		X	X
	Logistic Regression		X		X	X
	Non-linear Functions, Neural Networks					X
	Principle Component Analysis					
5	Overfitting					
	Overfitting Examples					
	Overfitting Avoidance					
	Complexity Control					
6	Similarity, Neighbors and Clusters					
	Similarity and Distance		X	X	X	X
	Nearest Neighbor		X	X	X	X
	Clustering		X	X	X	X

7	Decision-Analytic Thinking – Creating a Model					
	Evaluating Classifiers		X			
	Generalizing Beyond Classification					
	Expected Value					
	Outlier Detection					
8	Visualizing Model Performance					
	Ranking		X	X		
	Profit Curves					
	ROC Graphs and Curves					X
	Area Under the ROC Curve					X
	Lift Curves					
9	Evidence and Probabilities					
	Combining Evidence Probabilistically	X	X			
	Bayes Rule	X	X			
	Evidence Lift	X				
10	Representing and Mining Text					
	The Importance of Text				X	
	Text Representation				X	
	N-gram Sequences				X	
	Named Entity Extraction				X	
	Topic Models				X	
11	Decision-Analytic Thinking – Analytical Engineering					
	Selection Bias		X			
	Expected Value Decomposition		X			
12	Other Data Science Techniques					
	Co-occurrence and Associations					
	Profiling					
	Optional Scientist Firm Mentor Presentation					
	Link Prediction					
	Data Reduction					
	Bias, Variance, the Ensemble Method					X
	Data-Driven Causal Explanation Optional Scientist Firm Mentor Presentation					

	Time Series		X			
13	Data Science and Business Strategy					
	Achieving Competitive Advantage with Data Science				X	
	Sustaining Competitive Advantage with Data Science				X	
	Attracting Data Scientists and Teams Optional Scientist Firm Mentor Presentation				X	
	Evaluating Data Science Proposals				X	
	The Kaggle Model		X			
14	Ethics and Data Science					
	Data Security	X				
	Privacy	X	X		X	
	ACM Code of Ethics					