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Building a Business Data Analytics Graduate Certificate

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Building a Business Data Analytics Graduate Certificate

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ABSTRACT

In this paper we present the evolution of the Business Data Analytics Graduate Certificate (BDA Certificate) at our institution, Loyola University Chicago. This certificate is a successful and expanding program that attracts a diverse group of dynamic professionals from local, national, and international populations. The program evolution described in this paper involves multiple revisions of the curriculum, additions, and subtractions of individual courses, expansions of delivery methods, and program name changes. The core principles of acknowledging the centrality of data, mandating the modeling-based course sequencing, and recognizing the proper role of software tools, are outlined and recognized as the foundation of the program's success.

Keywords: Business analytics, Graduate certificate, Curriculum design & development, Data analytics, Graduate education, Business analytics curriculum

1. INTRODUCTION

This paper will present the evolution of the Business Data Analytics Graduate Certificate (BDA Certificate) at our institution, Loyola University Chicago. Currently, this certificate is a successful and expanding program that attracts a diverse group of dynamic professionals from local, national, and international populations. The program has undergone several changes involving multiple revisions of the curriculum, additions, and subtractions of individual courses, expansions of delivery methods, and name changes of the program. Throughout this evolution, we have learned several valuable lessons, which we outline in this paper. In contextualizing our BDA Certificate, our research also presents the most up-to-date summary of the business analytics (BA) curriculum development and implementation research stream, a valuable resource for our community as we continue to evolve and improve BA-focused education.

There are many different approaches to creating a successful business data analytics program, and we do not present our program as a singular template to be followed. Instead, we intend to make our experiences accessible to the wider community of academics who create and maintain programs with similar objectives and goals.

This paper is organized as follows: Section 2 presents a comprehensive literature review of the past and current state of data analytics and business analytics curriculum design and implementation. In Section 3, we define and discuss the founding principles of the BDA Certificate that drove the inception and development of this program at our institution. In Section 4, we outline the evolution of the BDA Certificate. In Section 5, we present and discuss the future of the BDA Certificate. Finally, in Section 6, we make our concluding remarks.

2. LITERATURE REVIEW

2.1 Data Analytics Overview

Data Analytics has become a widely accepted area in both academia and business. Expertise in data analytics is highly sought by employers in most industries. Students strive to add data analytics-related skills to their resumes and have a strong interest in learning how to find useful and actionable information in large amounts of data. The last decade has seen this discipline transition from a niche area to a broad area of interest accepted as extremely valuable by disciplines within and outside business.

Today's ability to analyze large amounts of data is possible only because of computerized data storage. With E. F. Codd's creation of relational databases in the 1980s and the development of SQL (Codd, 2002; Elmasri et al., 2000), businesses could store and retrieve data in efficient ways that were previously unfeasible. The area of Business Intelligence grew from this data availability. In the late 1980s, focus shifted from data collection and storage to finding information and knowledge within this stored data. We began to use the phrases "knowledge discovery" and "data-driven decision-making" (Frawley et al., 1992).

The emergence of data warehousing (Chaudhuri & Dayal, 1997) led to greater amounts of clean data being available to

answer business questions. Once this source of clean and consistent data became available to analysts and decision-makers, they asked, "What else can I discover?" The focus moved from building a data warehouse that could answer specific, pre-defined questions to collecting clean, integrated data to find answers to ad-hoc questions never asked before. For example, finding the best-selling products in different categories is a typical question a sales data warehouse is designed to answer. On the other hand, finding products that consumers tend to purchase together is a question that arose from the availability of historical transaction data in the data warehouse (Agrawal & Srikant, 1994; Nestorov & Jukic, 2003).

With the new opportunity, companies began looking for students who could analyze and integrate information, think analytically, and explain the results of their analyses to a general audience. The emphasis moved from the ability to use technology to improving company decisions (Elliot, 2012).

There were concerns that the conventional statistics methods, which have been the basis of data analysis for a long time, had limitations in their structure and the kinds of problems they could handle. The necessity of first generating a hypothesis and then testing it meant they might be missing great insights for which no hypothesis was formulated. In addition, statistics originated from a world where data was difficult to compile and often had to be entered manually, so techniques were not designed to scale to large amounts of data.

With the rapid growth of massive amounts of data stored and electronically accessible, analysts needed to develop new ways to optimize its use for analysis. This led to the development and application of numerous data mining techniques: association rule mining, cluster analysis, decision trees, neural networks, and support vector machines, to name a few. This ability to collect data rapidly, in many forms, and from a variety of sources could then be integrated, all of which led to a growing awareness in businesses that data is a valuable resource (Chiang et al., 2018). However, without skilled analysts to find the information contained in these datasets, they would turn out to be just very expensive storage. Companies now needed employees who could understand these new methods of analysis, apply them to their data, and employees who could better understand the customers and the supply chain, and gain this understanding speedily (Attaran et al., 2018). They turned to universities to supply people with such talents and skills. Thus, along with these new techniques, universities began adding courses that exposed students to this new way of approaching data analysis. Initially called Statistics II, the field gradually grew into its own, and is now referred to as Business Analytics in many schools. As John Tukey had argued in 1980 (Tukey, 1980), we need both types of analysis: that which confirms, and that which explores.

In the early 2000s, Data Science began to be used (Cleveland, 2001) as a broad term encompassing statistics, analytics, and machine learning. In 2011, McKinsey Global Institute predicted a major shortage of skilled data scientists, managers, and analysts dealing with data by 2018 (Manyika et al., 2011). This prediction was confirmed by reports of large shortages of hirable people in this area, with strong job prospects for the future (Piatetsky-Shapiro & Gandhi, 2018). Universities with business schools find these job prospects for students to be a motivating factor in the courses they offer, so it is not unexpected to find that the number of certificates and degrees in Business Analytics have grown, too. With an increasing shortage of people trained in analytics, more and more universities are moving into this area (Parks et al., 2018). The Institute for Advanced Analytics (2019) has an interactive map showing the locations within the U.S. of approximately 250 schools that now offer programs in analytics. They also show that the number of master's degrees in analytics and data science has grown from a negligible number in 2008 to over 20,000 degrees awarded in 2018. Entry-level positions average in the low $80,000s and Indeed shows over 65,000 entry-level positions available as of March 2022 (Indeed.com, 2022).

Increasingly, studies are being undertaken linking specific industry needs to specific coursework (Paul & MacDonald, 2020). Companies are moving from simply recruiting applicants with a specific degree to looking for an analytics workforce based on needed skills (Stanton & Stanton, 2020). Businesses are now also looking beyond basic training in analytics to analysts and scientists with experience or training in their specific industry (Matthews, 2019). That is, they want their hires to have seen and worked with not just data, but data from their particular domain area, and to be able to communicate the results of their analyses to non-technical team and company members.

2.2 Business Analytics (BA) Curriculum Literature

Our research is contextualized in Business Analytics curriculum-focused literature. The goals of this literature review section are to (i) identify key research articles, their publication outlets, key themes and issues raised, and provide a general landscape of BA program presence in business schools, (ii) evaluate whether there is a literature gap that our research can address, and (iii) inform and assist us in assessing the process we deployed in our institution. We present the most up-to-date summary of that research stream (see the Appendix), outlining the main contribution, sample size/method used, and program type for each manuscript. In the literature summary, we strictly focused on analytics in the business context (vs. data science) and curriculum assessment, design, and implementations (vs. BA course teaching cases).

This literature stream consists of 41 peer-reviewed manuscripts between 2009 and early 2022 (Figure 1). After first considerations of creating BI & Analytics focused programs in 2009 (Sircar, 2009), we saw an initial assessment of BA value and its potential between 2012 and 2014 (Chen et al., 2012; Chiang et al., 2012; Gorman & Klimberg, 2014; Wixom et al., 2014). Significant BA curriculum assessments and considerations were published in the 2015-2017 period (a total of 19), mainly focused on Big Data implications, classification of content domains and coursework, clarifying the difference between data science and business analytics, and recognizing gaps in the current IS curriculum standards (Topi et al., 2010). In the last five years, we see the literature focusing on the latest market trends such as certification integration (Shim et al., 2021) and changing competencies (Dong & Triche, 2020; Johnson et al., 2020; Ozturk & Hartzel, 2020; Stanton & Stanton, 2020). There is a recognition of the changing nature of BA in terms of job expectations, tools and their applications, and IS discipline identity (Ceccucci et al., 2020; Urbaczewski & Keeling, 2019) as a whole.

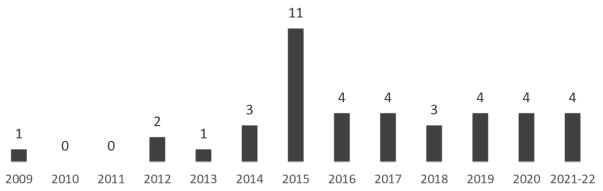

Figure 1. BA Curriculum Manuscript Count by Years (2009 - Present)

Selected manuscripts were published in 13 journal outlets and 6 different conferences (Figure 2). Leading Association for Information Systems (AIS) publications, systems-, and decision science-focused education journals are the primary targets for publishing BA curriculum research.

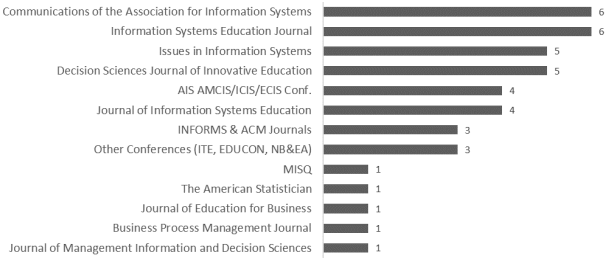

Figure 2. BA Curriculum Manuscript Count by Outlets (2009 - Present)

Thematically, BA curriculum literature assesses the state of the BA curriculum across a wide array of topics. These include BA value recognition and amplification (Chen et al., 2012; Chiang et al., 2012; Wixom et al., 2014), BA's impact on Information Systems discipline (Ceccucci et al., 2020; Chiang et al., 2012; Jafar et al., 2017; Urbaczewski & Keeling, 2019), BA program type classifications and their growth (Hameed et al., 2021; Mills et al., 2016; Stephens & McGowan, 2018), BA curriculum component categorization (Gupta et al., 2015; Kang et al., 2015; Mitri & Palocsay, 2015) and required coursework (Burns & Sherman, 2019; Ceccucci et al., 2020; Choi et al., 2017), skills and competencies (Deng et al., 2016; Dong & Triche, 2020; Johnson et al., 2020; Mamonov et al., 2015; Stanton & Stanton, 2020), common technology use (Johnson et al., 2020; McLeod et al., 2017), accreditation (Clayton & Clopton, 2019) and existing IS curriculum standards (Matthews, 2019; Mitri & Palocsay, 2015; Rodammer et al., 2015; Topi et al., 2010). The research commonly reports best practices and lessons learned in the process of implementation (Burns & Sherman, 2022; Clayton & Clopton, 2019; Hameed et al., 2021; Shim et al., 2021; Stanton & Stanton, 2020).

Most BA programs are rooted in the reality that the marketplace requires a workforce with solid analytics skills (Deng et al., 2016), suggesting a growing trend of offering business analytics-infused curriculum and BA programs in the forms of concentration within IS major or standalone majors (Mitri & Palocsay, 2015), minors, certificates (both undergraduate and graduate), MS degrees, and MBA concentrations (Gorman & Klimberg, 2014). Soon after initial research suggested the value of BA and its potential impact (Chen et al., 2012), the opportunity for business analytics academic programs was recognized (Chiang et al., 2012) and resulted in the rapid growth in programs (Wixom et al., 2014). A majority (60%) of AACSB IS programs added analytics-related courses between 2011 and 2016. By 2016, there was a dramatic increase in courses offered in big data analytics (583%), visualization (300%), business data analysis (260%), and business intelligence (236%) (Mills et al., 2016). A study in 2017 (using a random sample of 94 schools) found that about 64% of universities have developed business analytics programs at the undergraduate or graduate level, while about 40% offered BA certificates at the undergraduate or graduate level (Choi et al., 2017). Another study found that about 35% of schools offered BA program and about 26% offered BA minors or certificates at the undergraduate or graduate level (Phelps & Szabat, 2017), while a study in 2018 focused on peer private institutions found that about 50% offer any number of analytics-focused programs (Stephens & McGowan, 2018). More recently, over 65% of the AACSB schools (using a sample of 535 schools) offer a degree in business analytics concentrations at either or both undergraduate and graduate levels (Hameed et al., 2021). The emergence of the BA curriculum and student interest in BA reveal the trend of IS departments shifting their focus to data and data analytics, as IS represents the top subject domain of instructors teaching business analytics (Hameed et al., 2021). Consequently, many adopt the name "Analytics" into their traditional IS departments and degree names (Ceccucci et al., 2020; Urbaczewski & Keeling, 2019).

A significant portion of the early literature focuses on identifying core curriculum components. Several categorizations were proposed, such as: (1) business information intelligence, (2) business statistical intelligence, and (3) business modeling intelligence (Mitri & Palocsay, 2015); (1) analytical skills, (2) IT knowledge and skills, and (3) business knowledge (Chiang et al., 2012); four pillars of analytics (1) data preprocessing, storage, and retrieval, (2) data exploration, (3) analytical models & algorithms, and (4) data product (Kang et al., 2015); (1) business expertise, (2) applied statistical analysis, and (3) technical skills (Mamonov et al., 2015); (1) data management, (2) statistics, and (3) core data analytics (Jafar et al., 2017); and eighteen topic areas (Gupta et al., 2015).

These categorizations were often followed by identifying required courses and their mapping to the aforementioned categories and program types. For example, literature focused on BA minors found that, on average, business analytics minor programs have two prerequisite courses, three required courses, and two electives (Burns & Sherman, 2019). On the other hand, BA certificates require between three and six courses (Choi et al., 2017). The same literature stream suggests that most BA programs' top three required courses include a database, predictive analytics, and introduction to BA course (Ceccucci et al., 2020).

Graduate-level BA education is particularly critical as roughly 35% of the entry-level BA jobs on the market prefer professionals with graduate degrees (Johnson et al., 2020). Many schools responded to that call and initially implemented graduate BA-focused programs (Mitri & Palocsay, 2015). At the graduate program level, significant variations in the program structure in terms of program length (10 to 18 months) and flexibility (electives comprise 0 to 37% of the course work)

were reported (Mamonov et al., 2015). In a sample of six universities, most graduate BA programs (i) allocated courses across three areas: business expertise, applied statistical analysis, and technical skills, (ii) focused on areas that leverage institutional strengths, and (iii) started integrating practical training and internships as part of their BA curriculum (Mamonov et al., 2015). Others suggested a graduate-level analytics curriculum consisting of five areas: data management, statistics, core data analytics, capstone, and electives (Jafar et al., 2017), with a focus on competencies (Mamonov et al., 2015) and skills demanded by the marketplace, such as tools, big data infrastructure, technical concepts, and soft skills (Johnson et al., 2020). Distinct curriculum needs and market expectations are reported for those completing MBA versus those completing MS in IS or BA (Dunaway & McCarthy, 2015; Gupta et al., 2015; Jafar et al., 2017; Parks et al., 2018; Warner, 2013).

Regarding technology used, the literature suggests that the programs vary greatly in covering both traditional analytics and the new emergent technologies and analytical methods. SQL, R, Python, Excel, and Tableau are among the BA field's most desired programming languages and tools (Johnson et al., 2020). The programs that focus on Big Data and its infrastructure reported common use of platforms such as Hive, AWS, Azure, Hadoop (Johnson et al., 2020), and SAP HANA (McLeod et al., 2017), elevating the need for continued faculty retooling and aligned hiring practices (Hameed et al., 2021).

Calls have been made for guidelines in creating and assessing the BA curriculum and programs (Wixom et al., 2014). A wish list of guidelines for "dream" BA program development has been introduced (Wang, 2015) and applied (Wymbs, 2016). Those guidelines include (1) developing interdisciplinary courses, (2) aligning BA course offerings with the needs of practice, (3) considering using real-world projects, (4) capturing the union of relevant disciplines, and (5) strengthening the faculty members' BA expertise (Wang, 2015).

In summary, our literature review captured critical research articles suggesting continued interest by the IS community in the building, improving, and, increasingly, adopting BA programs as the discipline's key identity. The research on this topic has been relatively steady in the last seven years, after its peak in 2015, and is primarily published in leading IS and Decision Science education journals and leading IS conferences. The literature covers a wide array of topics, focusing on the growth and impact of BA on the IS discipline, curriculum components clarifications, and best practices, understanding market-driven skill expectations, and evaluating the use of technology and programming languages. The literature summary also revealed a general lack of in-depth description, reflection, and understanding of BDA graduate certificate programs, their opportunities, challenges, and required modifications to remain relevant. Given the shortage of data analytics skills, these programs are valuable and essential in addressing the deficit, retooling the workforce, and providing a viable path to a full graduate-level degree. Therefore, sharing our story of the BDA Certificate has the potential to enrich the existing literature and inform the academic community considering implementing or modifying their own BA programs.

3. BDA CERTIFICATE FOUNDING PRINCIPLES

Before we describe, in chronological order, the evolution of the BDA Certificate at our institution, we will first outline certain basic founding principles that guided and continue to guide, our decisions from the inception to the previous, current, and future versions of the program. As we will describe later in this paper, we have been through several changes since the foundations for this program were laid out over twenty years ago. Throughout this evolution, we have had both successes and failures. We also had to make, and continue to make, some compromises that were not always ideal. However, we consistently recognized that adhering to the core principles presented in this section was the correct course of action that ultimately enabled this program to prosper. In particular, the three principles that continually guided the development of this program are: the centrality of data, modeling-based course sequencing, and the proper role of software tools.

3.1 Centrality of Data (Principle #1)

When it comes to teaching curriculum that deals with data utilization, the consensus among faculty at our department is that the data itself should be at the core of learning. In other words, the point is to first focus on the data itself, before we study the methods of analysis and explore the actions and opportunities that the data can afford us. In a practical sense, this means to put the modeling and structuring of the data as the foundation and a prerequisite for all other courses.

In other words, data organization and modeling are paramount and central to everything else we do in our data-related curriculum. A strong data foundation is necessary for storage and retrieval, modeling and transformations, and analysis and visualization. We also find support for this principle in our literature. From a market expectation perspective, data preprocessing (closely linked to our principle #1) is still considered a dominant skill. A study evaluating top skills in analytic job posts found that the top required skill was "database management" (65.8% of ads), while the sixth most required skill was SQL (56.6%). Both skills are enabled by and require understanding data, its structure, and modeling (Dong & Triche, 2020). A similar finding comes from another study suggesting that one of the top two most desirable hard skills for entry-level analytics positions includes data modeling (Stanton & Stanton, 2020). Our formal and informal interactions with analytics professionals and alumni confirm these findings and the centrality of data.

3.2 Modeling-Based Course Sequencing (Principle #2)

In many instances, business data analytics is promoted as enabling actions that can lead to positive change. While that is true, it also often leads to teaching business data analytics by immediately jumping into the methods of analysis and showing a variety of possible actionable outcomes. Our approach differs from this common scenario. Starting a BA program with a course that focuses on how data is structured (i.e., Database Course) before learning how data is analyzed is not the norm in many BA curriculums. For example, we looked at dozens of similar programs (Data Analytics certificates at reputable US-based universities) and found that only two of them offer a course in databases or a similar course on how data is organized.

In conjunction with the basic principle outlined above in sub-section 3.1, we adhere to a specific guideline for

sequencing of courses, where a course on database modeling will be a prerequisite for covering topics that deal with data analysis. We feel very strongly that students, in any course dealing with data analytics, must have knowledge about how data is organized. Therefore, skills such as entity-relationship modeling and relational modeling must be mastered before actual analytical skills are learned. Understanding metadata, if data is organized and prepared for analysis, or data preparation, if data is not prepared for analysis, is mandatory for any serious data analytics effort. Therefore, learning the methods that enable understanding of metadata and data preparation (including structuring, re-structuring, and cleaning of data) before learning methods for analyzing data is critical.

3.3 Proper Role of Software Tools (Principles #3)

We acknowledge the need to include state-of-the-art software in a business data analytics curriculum. However, when it comes to software tools, we subscribe to the view that tools are a means to an end, where the end is more important than the means. In other words, the focus should be on the concepts the software tools implement rather than on the proprietary details of how those concepts are employed in particular packages. Our intent is not to showcase students' fluency and comfort level with a particular software or platform. Instead, they should be recognized for their knowledge of principles, methods, and problem-solving skills.

We expect our students and graduates to be able to seamlessly and quickly switch between using competing software, such as various data modeling tools, DMBS platforms, data mining software, data visualization packages, and tools of the future, based on their knowledge of methods and principles encapsulated in these tools.

Regarding the data centrality principle (principle #1), we recognize that if data analysts do not have a professional understanding of how data is organized, they cannot optimally use their analytical skills; i.e., it is often difficult to analyze data if one does not understand how it is organized and why it is organized the way it is organized. Once data centrality is acknowledged, the modeling sequencing principle (principle #2) becomes essential for achieving it. Lastly, if we do not institute principle #3, we render the program a narrow, vendor-proprietary educational effort rather than a true, universally applicable degree.

4. BUSINESS DATA ANALYTICS CERTIFICATE EVOLUTION

In this section, we will chronologically outline the evolution of the BDA Certificate program at our institution. This outline will serve to underscore how both internal and external factors and events influenced and shaped our program. We will outline both the initiatives that resulted in progressive success as well as the ones that outright failed or had to be abandoned. All of them were important in providing us with the experience and expertise to continually improve the program.

4.1 The DWHBI Certificate (Prior to 2007)

The first precursor to the BDA Certificate at our institution was the Graduate Certificate in Data Warehousing and Business Intelligence (DWHBI Certificate), launched in 2001 by the information systems group at the School of Business at our institution. This certificate was put together to supplement the MBA degree and the other graduate degrees while simultaneously showcasing two newly created graduate business courses: Data Warehousing, and Data Mining. In the 1990s and early 2000s, both Data Warehousing and Data Mining were relatively new, growing areas enjoying strong industry demand accompanied by the lack of professionals with proper education in these areas. The DWHBI Certificate was created to capitalize on these trends.

The certificate was created as a 5-course program, where students began by taking the Database Systems course and then proceeding to take the Data Warehousing and Data Mining courses. Two electives followed these. At that time, the Database Systems course was already mature with an in-depth coverage of database requirements, database conceptual modeling (ER modeling), database logical modeling (relational modeling) and normalization, SQL, and issues related to database implementation and administration. For database modeling, we used our own home-grown application called FatFreeERD, which students could install for free on their computers. This application's capability for drawing ER diagrams and relational schemas was used in the modeling part of the class. The DBMS platform that was used for SQL was Oracle, which was acquired through participation in the Oracle Academic Initiative. This program allowed academic institutions access to Oracle technology and MS Access.

The newly created Data Warehousing class was designed to be taken after the Database Systems class. As in the Database Systems class, this class heavily emphasized data-modeling. The main focus was, of course, on modeling analytical data repositories, namely data warehouses and data marts. In particular, the class heavily emphasized dimensional modeling with star schemas. The FatFreeERD application was utilized, as it can also draw star schemas. Other data-warehouse related topics, such as the extract, transform, and load process (ETL), and OLAP/BI were also covered, but in a strictly theoretical manner.

The Data Mining class also had the Database Systems class as its prerequisite. This class began in the mid-90s and built on the skills developed by the students in their database class. Data mining was introduced as the process of discovering meaningful patterns in large amounts of data, though the meaning of "large" has evolved since the mid-90s. Originally, we used a software tool, Clementine, which had been acquired by SPSS and Excel for data analysis. Students were required to build a database, export the data into an Excel spreadsheet, and load it into Clementine to run data mining models. Emphasis was placed on data understanding, model understanding, analysis of the model output, and application to business problems. All students were required to complete a project following the CRISP (CRoss-Industry Standard Process) process (Wirth, 2000).

These three courses (Database Systems, Data Warehousing, and Data Mining) formed the program's core and were mandatory for all students enrolled in the certificate. Per administrative rules of the university, this certificate was designated as a five-course program. Therefore, the program had to include two more courses. The decision was made to list several Marketing courses as possible electives. To acquire the DWHBI certificate, students had to take two of these applied elective courses. These included courses on Business to Business Marketing, Integrated Marketing Communication, Digital Marketing, Database Marketing Strategy, Customer

Relationship Management, and Internet Marketing Strategy. The structure of the program is illustrated in Figure 3.

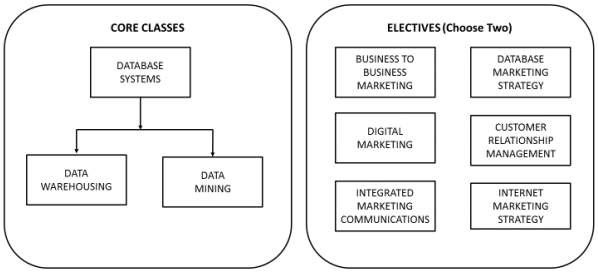

Figure 3. DWHBI Certificate Curriculum Prior to 2007

At that time, marketing was (at least internally in the School of Business) regarded as the main client of analytical data and as such, an appropriate supplier of elective courses for the certificate. Administration at that time was satisfied that the Information Systems group was able to fulfill the requirement for a five-course sequence in the requirements and that the Marketing group was able to increase the enrollment in their courses by adding the DWHBI Certificate students.

The certificate students were generally satisfied with both the core and elective classes. They reported that there was very little connection between the two groups of classes, but they liked acquiring the data management and analysis skills they viewed as supplementary to their main area of study. This was not understood to be a critical issue since the certificate was awarded mostly to the students already enrolled in one of the master's programs at the graduate school of business, as all of the courses in the certificate also counted towards their master's degree. In fact, no separate enrollment figures for the DWH/BI certificate were kept during this period.

The program during this period is a combination of convenience and compromise. There was little communication and coordination between the Information Systems and Marketing faculty. Both groups viewed the certificate as a side initiative that enabled graduate business students that took certain courses from both areas to acquire an additional credential.

4.2 DWHBI Certificate (2007 – 2015)

By 2007 the curriculum context at our institution was starting to change as the data-related issues were perceived as increasingly valuable, not only by the Information Systems department but also by other departments. One of the consequences of this new focus was the decision to start viewing the DWHBI certificate as its own program as well, rather than just as a supplement to the existing master's programs at the School of Business. The five-course certificate was still offered as an elective component of the master's programs at the School of Business (a relationship that continues to this day) but an effort was undertaken to promote it also as a credential that could be acquired by students joining our graduate school of business just for the certificate.

The leadership of the DWHBI certificate undertook an audit of all graduate classes at the School of Business and identified the courses that had greater relevance and connection to the DWHBI Certificate, and as such, added them to the list of electives, as shown in Figure 4.

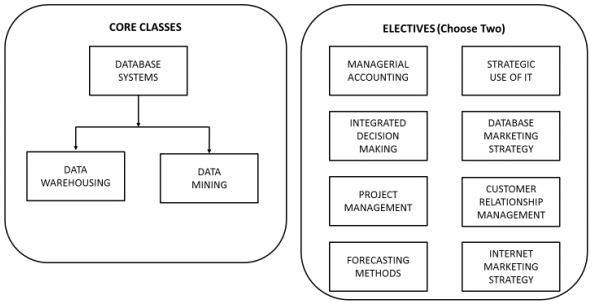

Figure 4. DWHBI Certificate Curriculum 2007-2015

The list included courses on Managerial Accounting and Integrated Decision Making from the accounting department as well as Project Management and Forecasting Methods courses from the operations management area. In addition, another Information Systems course was identified as an elective: Strategic Uses of IT. Several Marketing classes from the previous list of electives were dropped (as they were perceived as not sufficiently relevant for the DWHBI certificate), while three remained: Integrated Marketing Communications, Database Marketing Strategy, and CRM. At this time, the Information Systems faculty engaged with all of the faculty teaching elective courses, and all agreed that elective courses should be integrated in a way that aligned with the mission of the DWHBI certificate. At the same time, all the core courses were undergoing changes and additions.

The Database Systems course started using the newly launched, free, web-based open-suite ERDPlus (erdplus.com) for the data modeling aspect of the course. In addition to continuing to use Oracle for the SQL portion of the class, students were also provided with the access to Teradata DBMS through a membership in the Teradata University Network initiative. The Data Warehousing class maintained its heavy focus on modeling and switched to using the ERDPlus to create star schemas. Other topics were now covered in a much more applied way, including using Informatica software for ETL and Tableau for OLAP. Big Data topics were introduced, and Greenplum MPP and MapReduce Hadoop platforms were included in the coursework.

By 2007, Data Mining had evolved, as had the tools available for its application. SPSS has continued to expand and improve its product. The software name was changed to Predictive Analytics Software (PASW), and the number of data mining tools had expanded to reflect the software's new orientation. The ability to load data from various sources was also made possible. The course continued to include association rule mining, cluster analysis, decision trees, and neural networks as focus techniques. The course used several cases from different business fields, and students were still required to complete a project that followed the CRISP methodology.

Since the DWHBI certificate was now viewed as more than just a supplement to the existing master's degrees, enrollment into the certificate started to be actively monitored and tracked. The enrollment numbers for the DWHBI certificate during this period oscillated widely, as shown in Figure 5. Since this period coincided with the great recession that started in 2008, it is not easy to evaluate the effect of the quality of the curriculum and

courses to the enrollment itself. But, certainly, the numbers have mostly grown, as compared to 2007.

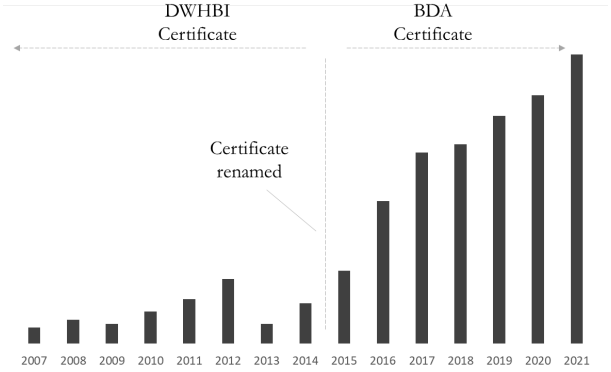

Figure 5. DWHBI/BDA Certificates Awarded (Compared to 2007)

Note that enrollment numbers in this paper are given as ratios. Due to privacy and competitiveness reasons, we do not have permission from our institution to give exact numbers or demographic breakdowns. The ratios still provide an illustration of progress and trends.

4.3 Business Data Analytics Certificate (2015 – 2021)

With the attention that the broad field of Business Data Analytics was gaining, and considering that all three core classes in the DWHBI Certificate were fundamental and integral parts of Business Data Analytics, the decision was made to revamp the certificate and rebrand it as the Business Data Analytics (BDA) Certificate. It became apparent that the terms Data Warehousing and Business Intelligence were being perceived as somewhat narrow and technical, especially compared to the term Data Analytics, which was becoming very popular and had a much broader appeal.

Serious analysis of the DWHIBI Certificate curriculum and the entire graduate school of business curriculum was undertaken. For the newly named BDA Certificate, the decision was made to consider only courses where the data and/or data analysis was one of the central themes. The intent was to identify courses that either contain elements and methods that are useful and instrumental for business data analytics or integrate business data analytics with the application topics that they cover.

The decision was made to keep all three core courses in place as they were as fundamental to the mission of the new certificate as they were for the old one. Next, the evaluation of the electives from the 2007-2015 period was undertaken. Due to various reasons, ranging from not having data and analytics as the main focus (for example, Strategic Use of IT, Project Management) to changes in the course syllabus and/or turnovers of faculty teaching the courses resulting in the change of course focus (which occurred every couple of semesters and in too many cases instructors were allowed to change classes completely, often minimizing the data analytics aspect), all previous electives, except the Forecasting course, were eliminated from the certificate. This is illustrated by Figure 6.

At this point, the emergence and prominence of data analytics as a broad business phenomenon was reflected in the fact that several departments at our School of Business created one or more course in their field with a focus on data analytics. Those courses used knowledge from our base analytics trio of classes but with applications in their specific areas. Those courses included Human Resources Data Decision Making, Supply Chain Analytics, Marketing Metrics, and Customer Analytics. Unlike the electives of previous iterations of the DWHBI certificate, these domain-specific courses were created and taught by faculty with a solid background in data organization and analysis topics, in addition to their expertise in their respective domains. Also illustrated by Figure 6 is the number of new courses added to the list of electives. The existing Applied Econometrics class in the economics department was identified as having the analysis of data as its main focus and, as such, appropriate for inclusion in the list.

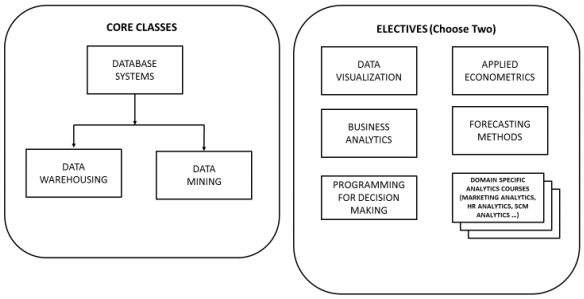

Figure 6. DWHBI/BDA Curriculum 2015-2021

In addition, several new courses were created in the Information Systems department. One of those was a new course on Data Visualization. This course consists of three main parts. The first part of the course covers data visualization theory, including categorical and quantitative variables, basic chart types, visual distortion and the "Lie Factor" formula, and chart evaluation. Students learn these theoretical concepts and apply them to many chart examples. Group exercises in class are one of the key components of the first part of the course. The second part of the course focuses on using Tableau, one of the most widely used software tools for data visualization. Students learn the fundamental building blocks of charts and how to implement them in Tableau. Some unique features include the custom-made top-K chart module, parameterized and flexible histogram module, and custom rank module. The last part of the class focuses on dashboarding and storytelling. The course also involves a quarter-long group project that requires the analysis of a real-world dataset. In lieu of a final, students present their project findings using dashboards and stories in Tableau in a formal setting.

Another information systems course included was a programming course titled Programming for Decision Making. For several years, we relied on the Computer Science department for courses related to coding. Over time, our students began asking for a coding course with specific applications in business. We began with Visual Basic, moved to C#, then to VBA with a strong emphasis on coding in Excel, then to R, and finally to Python. We currently offer VBA, R, and Python courses. The programming language focus change is partially driven by the evolution of languages and their acceptance by the industry and is in line with trends identified in our literature review (Dong & Triche, 2020; Johnson et al.,

2020; Ozturk & Hartzel, 2020; Stanton & Stanton, 2020). Also, we expose our students to a variety of coding approaches. We continually monitor real-world developments, especially regarding skills expected of entrants to the job market.

We strongly believe that coding is a good skill in which to develop competence for several reasons: First, it strengthens a student's logical thought process, and second, it takes the mystery out of what is often perceived as an inaccessible area (as many students think of mathematics or statistics). We also believe that the language of choice will continue to change, but the skills will remain constant. We have accepted that the language we offer will be a moving target.

Another new course, titled Business Analytics, was added to the list of electives. This course was designated as a BSAD (Business Administration) course, indicating that it did not belong to one particular department at the school of business, even though the information systems department managed it. This particular course was envisioned as a course that would provide students with the basic instruction of the R language while at the same time being a broad course that would give students a high-level overview of data mining, data visualization, and other information systems tools and methods for data analysis, in a way that can serve as a standalone course for the members of our MBA population who only want to take one course (instead of the entire BDA Certificate). At the same time, the course serves as an introduction to and building block of the certificate for students interested in completing the whole certificate. While the BSAD course touches on various BA approaches and methodologies, including an introductory discussion of Data Mining, standalone Data Mining was still needed in our BDA curriculum, as it delves much deeper into data mining topics.

In 2020, we added one more elective Information Systems course (online/asynchronous), which proved to be extremely popular (proven by large enrollment in the inaugural version of the class and a high student evaluation score for the course (4.8/5) and instructor (4.9/5) effectiveness) by both graduate certificate students and those in other MS and MBA programs (as elective). The course, Applications of Visualization is envisioned to introduce the UX side of data visualization to our students. In this experiential and hands-on course (using Tableau), students develop a vocabulary and framework for discussing, critiquing, assessing, and designing visual displays of quantitative data. This class focuses on the awareness and application of human perception and cognition (gestalt laws, preattentive attributes, color, memory, cognitive effort, etc.), best design practices in visualizing quantitative data, dashboarding, and interacting and storytelling with data. As the analytics curricula mature, it is clear that the UX side of analytics is becoming a critical skill set for our graduates. Their interest in this course, student satisfaction rates (previously noted evaluation scores and a high Net Promoter Score of 80), and resulting professional impact confirm the value of this type of content. Here are just sample statements of the impact this newly created course has had on our students:

- "I printed out one of the homework assignments to bring with me to my interview… I think this made me stand out in my interview which led to an immediate offer after."
- "I've started getting projects at work revolving around class content - it has helped tremendously!"
- "This course has helped me in creating visualization, sometimes even simple charts were drastically improved with minimizing cognitive effort. My supervisor's supervisor even commented on how well I improved a monthly report."
- "The skills learned in this class will set you apart as a professional and possibly open up opportunities into data analytics."
- "I think this is one of the best courses I have taken. The content is highly relevant and applicable in the workplace..."

The content choices for our courses and their dynamic modifications over time are a result of several factors: our understanding of market needs, alignment of relevant standards and available literature, and faculty content and research expertise, collaboration and leadership. We maintain contact with the marketplace and its needs through close contact with our alumni (many now with leadership roles in large corporations and consulting firms) and regular university, department, and program-sponsored formal and informal events. Furthermore, we rely on the expertise of our faculty members who (i) are on boards of local companies, (ii) published leading database, data warehousing, and programming textbooks, (iii) run consulting practices focused on data analytics, and (iv) operate research labs such as UX and biometrics lab.

As shown in Figure 5, the switch from the DWHIBI certificate to the BDA Certificate coincides with a significant increase in enrollments. While it is entirely possible that some or even all growth was driven by the increase in data analytics within business schools, the enrolled students often verbalized that the branding change allowed them to view the core courses in the certificate as both approachable and widely applicable, while the choice of electives proved to be both plentiful and satisfactory. Evidence of our success includes very positive teaching evaluations (where students' comments repeatedly refer to the "approachable" and "applicable" nature of the courses), as well as results of conversations with students during the application for graduation process. These are voluntary, but nearly half of the students participated. During these conversations, core principles are routinely discussed with students who confirm their positive effect on curriculum and job search. It was common to hear from our BDA "alumni" that our BDA courses were instrumental to securing a new job or completely pivoting their careers.

4.3.1 Accelerated and Online Versions of the BDA Certificate. As the BDA Certificate enrollment continued to grow, we decided to offer our students different ways of completing the certificate. Traditionally, all courses at our graduate school of business are offered in person at our campus location. The courses are offered on a quarterly basis, where each course meets once a week (typically 6-9 pm in the evening) for ten weeks. All our graduate programs, including the BDA Certificate, can be started during any of our quarters: Fall, Winter, Spring, or Summer. Students complete the BDA Certificate in as quickly as two quarters or as slowly as five quarters (if they are taking only one course per quarter).

In the Summer of 2017, we decided to offer an accelerated version of the BDA Certificate, with each course meeting every day for two weeks at our downtown location. The students in

this accelerated intensive program spent 3 hours daily in the classroom. A single class could be completed in two weeks. Courses were offered in sequence, enabling students to complete the 5-course certificate in 10 weeks. In addition to the three core courses, two electives were chosen for inclusion in the accelerated version: Data Visualization and Business Analytics. The program succeeded with good course enrollment and generally favorable student feedback. The same accelerated program was repeated in the summer of 2018.

At that time, the decision was made to create an asynchronous online version of the five courses in the accelerated program. The accelerated online asynchronous certificate was offered to a limited group of students in 10 weeks during the winter of 2018-19. We had concerns about how the students would fare in such an intensive program done in a relatively isolated fashion, but to our surprise, the five courses in this accelerated online version received positive feedback from the students. We compared students' feedback using course evaluations across two formats (accelerated vs. 10-week) and found either no difference or, surprisingly, preference for the accelerated version in one instance (taught by the same instructor) as measured through students' assessment of Material Learned (+0.1 difference), Overall Course Effectiveness (no difference), and Instructor Overall Effectiveness (+0.2 difference).

Based on this experience, in the summer of 2019 we delivered the accelerated version of the BDA Certificate in the asynchronous online format. The program generated a lot of interest and we had to cap the enrollment for it. The attendees very positively evaluated the program, and we had another iteration in the same format for the summer of 2020, which was equally successful. At our institution, Information Systems and all business courses have high course evaluation averages and are viewed as exemplary by the university administration. In this environment, the BDA Certificate did even better. For example, in student evaluations, the BDA Certificate courses were evaluated in the Overall Course Effectiveness on a 5-point scale, 0.1 points higher than all graduate Information Systems courses and 0.3 points higher than all graduate business courses. In Material Learned, the difference was 0.3 and 0.5 points higher, respectively. The format remained popular with our students and contributed significantly to the continued growth of the certificate.

4.3.2 Influence of the BDA Certificate on the Undergraduate Program. As the BDA Certificate (and its predecessors) evolved at our institution on the graduate level, we were able to create continually and include information systems courses with equivalent topics in our undergraduate program. For example, as we introduced a standalone Data Visualization graduate class for the BDA Certificate, we also introduced an equivalent standalone Data Visualization class for the undergraduate program. Similar scenarios occurred with other classes. In each case, the initial impetus for a new course was the intent to improve the BDA Certificate, and then it was logical to expand the undergraduate program with an equivalent course as well.

5. BDA CERTIFICATE FUTURE STATE

At this time, our BDA Certificate program is thriving, and we are satisfied with all of its aspects, including the course offering, enrollments, and the professional outcomes of our students. For example, in the current setup, our students can get instruction in SQL, R and Python, which is aligned with the current situation wherein SQL, Python, and R are the primary programming tools used by analytics practitioners in the industry (Johnson et al., 2020).

However, we are under no illusions that we have reached a stable state that will remain unchanged for years to come. At this stage, when it comes to a business data analytics curriculum, change is a certainty, and maturity is not probable (at least not in the near term). Technologies and methodologies, job market, student needs, methods of delivery, competitors, and other factors are all subject to continuous changes.

The future will undoubtedly bring challenges, opportunities, and changes. For example, we recently developed a course covering data storytelling and user experience. We are already working on developing additional courses that we may include as future elective (or even core) courses for the certificate. The new courses we are considering would cover business requirements for analytics, machine learning life cycle, AutoML tools (such as DataRobot), advanced R, etc. At the same time, we are reluctant to require more than five courses for a certificate degree. Therefore, our challenge will be incorporating many diverse paths into a singular BDA Certificate.

One trend that may positively impact future graduate offerings, including the BDA Certificate, is the growth patterns in our undergraduate program. The patterns are quite similar to the growth in the BDA Certificate. Figure 7 shows the increase in enrollment in our undergraduate program in the 2007-2021 period. A comparison of Figure 7 with Figure 5 reveals similarities.

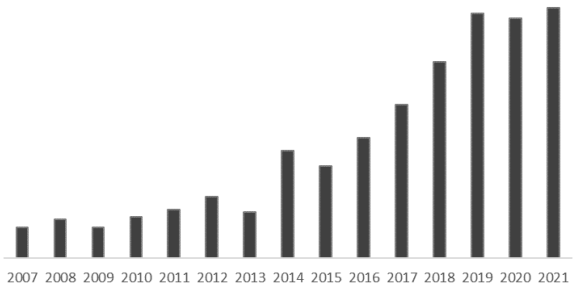

Figure 7. Information Systems (Undergraduate) Majors Graduating (compared to 2007)

Perhaps not surprisingly, we are seeing an uptick in former undergraduate IS students pursuing both BDA Certificates and our MS IS-focused programs. We are responding to this pool of students by giving them credits for some classes. For others, we provide guidance in selecting advanced topics and newer courses that exist only at the graduate level.

Another emerging issue is the need to offer the certificate in a variety of formats, including in-class, online, and hybrid, providing the students with the flexibility to take their five courses in whatever mixture of these formats they prefer. This will require an increase in our resources and innovative scheduling options. This also may require adopting new measures for assessing the quality of teaching and learning (MacLeod et al., 2019).

Lastly, prompted by the success of the BDA program, in the Fall of 2020, we launched Masters in Information Systems and Analytics Program. This program builds on the foundation of the certificate and enables a deeper dive into information systems and analytics topics.

6. CONCLUSION

In conclusion, in addition to our three founding principles, we adopt the guidelines ("dream" BA program) introduced in our literature review (Wang, 2015) to assess the process used in our BDA evolution. First, we developed and incorporated interdisciplinary courses in every iteration of our program evolution. In our case, this was primarily implemented through elective courses. However, our program's list of electives was initially extensive and lacked data focus. Over time, we narrowed the list of interdisciplinary courses. Second, we closely aligned BA course offerings and their content with the practice's needs. Our faculty expertise and their close interaction with practice informed our three founding principles to ensure alignment with market needs when it comes to critical thinking, data, analysis methods, and tool skills. Third, our courses include a mix of theoretical knowledge and experiential learning using real-world projects and resulting data and project management challenges. The inclusion of additional real-world projects continues to be an area of opportunity. Fourth, the program captures the union of relevant disciplines, which, in our case, currently include statistics and econometrics, programming, IS, and SCM/Forecasting. Lastly, we strengthen the faculty members' BA expertise through continuous training, strategic hiring, insistence on adopting all instructors' founding principles, and talent realignment.

In this paper, we have presented the process of building the BDA Certificate at our institution and the evolution that included multiple curriculum revisions, additions and subtractions of individual courses, expansions of delivery methods, and program name changes. Ultimately, the success of our program was based on the core principles of acknowledging the centrality of data, mandating the modeling-based course sequencing, and recognizing the proper role of software tools.

We do not assert that how we built our BDA Certificate program is the only way to go about business data analytics academic programs (which may include vendor-specific certificates, focusing on one component of BA, and various forms of domain-specific BDA certificates, to name a few). Instead, we have described in this paper how that worked for our circumstances and our constituency in an ever-changing area. We believe that sharing our story can help the readers understand the steps in this fluid process as they embark on their own BA curriculum initiatives.

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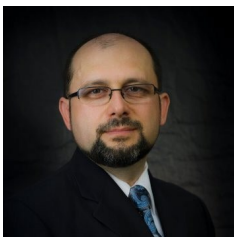

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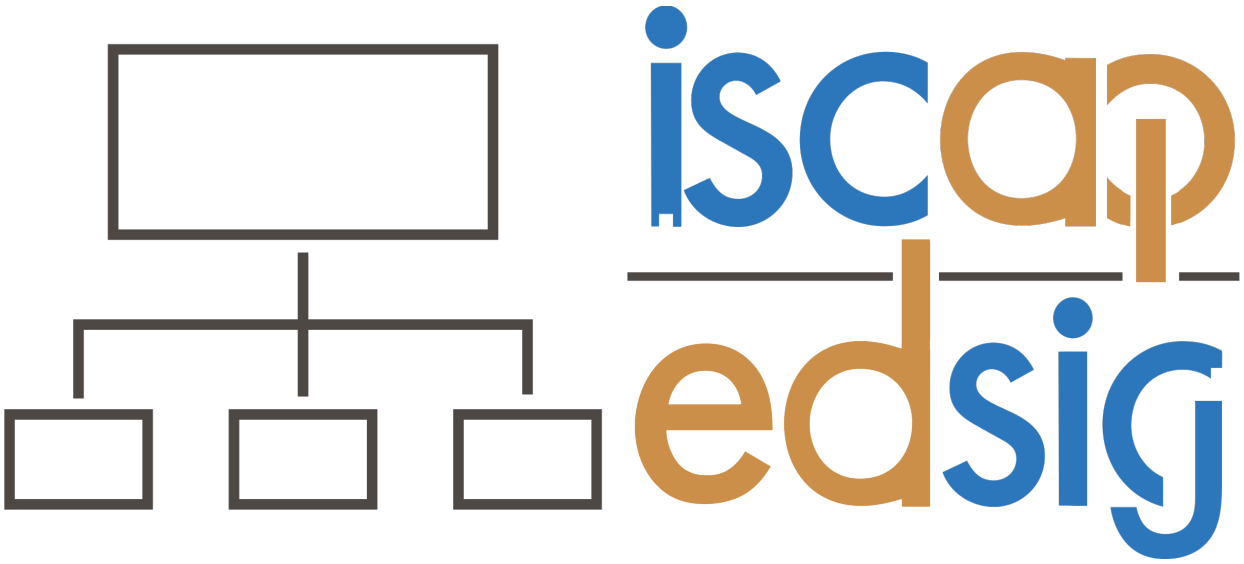
APPENDIX

BA Curriculum Manuscript Summary

Year	Manuscript	Contribution	Data Source(s)	Type
2022	(Burns & Sherman, 2022)	Lessons through a reflection on the process of BA minor creation	Single school focus	Undergraduate
2021	(Hameed et al., 2021)	Overview of BA program offering and faculty background.	535 AACSB schools (US)	Undergraduate and graduate
2021	(Shim et al., 2021)	Integrating professional certification with four courses in the undergraduate BA track.	Single school focus	Undergraduate
2020	(Ceccucci et al., 2020)	The overlap between the BA and the Information Technology degree programs.	225 AACSB schools	Undergraduate
2020	(Dong & Triche, 2020)	Common set of skills required across BA jobs and highlighting gaps in undergrad. curricula.	29 universities	Undergraduate
2020	(Johnson et al., 2020)	A framework for MSBA curriculum by identifying BA practitioners' concepts, skills, and tools.	15 MSBA programs	Graduate
2020	(Paul & MacDonald, 2020)	Comprehensive analysis linking specific industry needs to specific coursework that allows any university to create a well-rounded BA program.	Industry, literature, and 18 universities	Undergraduate and graduate
2020	(Stanton & Stanton, 2020)	Identification of job titles, credential and skills required for BA jobs along with program changes to prepare students for BA career requirements.	Literature	Undergraduate
2019	(Burns & Sherman, 2019)	Assessment of BA minor structures	65 randomly selected schools	Undergraduate
2019	(Clayton & Clopton, 2019)	AACSB accreditation concerns and BA certificate developmental process.	Single school focus	Undergraduate
2019	(Urbaczewski & Keeling, 2019)	Critical discussion of MIS departments transition to Analytics departments	Literature	Undergraduate and graduate
2018	(Parks et al., 2018)	Explore MSBA programs from top business schools and investigates their content.	62 programs	Graduate
2018	(Rienzo & Chen, 2018)	Analytics curriculum development roadmap is offered by examination of evolving analytic needs through the lens of disruption theories.	Literature	Undergraduate and graduate
2018	(Stephens & McGowan, 2018)	Identify four overarching issues in BA curricula literature and provide BA curricula development recommendations.	24 private universities and literature	Undergraduate
2017	(Choi et al., 2017)	Overview of how U.S. universities have designed and implemented BA programs/courses in terms of the degree (major, minor) and certificate program, and the number of courses.	94 AACSB schools	Undergraduate and Graduate programs
2017	(Jafar et al., 2017)	Made the case (and a curriculum template) that a Master's degree in data analytics is the right place for IS educators start the assimilation of the data analytics phenomenon.	13 graduate programs and single school focus	Graduate
2017	(McLeod et al., 2017)	Compare curricula usage by SAP member schools to evaluate changing curriculum.	SAP member schools' requests	Not specified
2017	(Phelps & Szabat, 2017)	Statistics perspective on the content and who is teaching business analytics courses	17 universities	Undergraduate
2016	(Mills et al., 2016)	Explored the growth of analytics, BI, and big data content in AACSB IS programs between 2011 and 2016. The growth is analyzed through the mapping of courses to four pillars of analytics.	118 AACSB programs, literature	Undergraduate and graduate
2016	(Turel & Kapoor, 2016)	The analysis of BA-related course offerings and subsequent BA-maturity ranking of institutions	124 schools (414 courses)	Undergraduate and graduate

2016	(Wymbs, 2016)	Developing and managing BA curriculum using innovation theory. Two-phased curriculum approach: program mission & accreditation and course design.	Literature, Single school focus	Undergraduate
2015	(Aasheim et al., 2015)	Assessment of similarities and differences between undergraduate BA and data science programs.	13 universities	Undergraduate
2015	(Dunaway & McCarthy, 2015)	Lessons in the development and implementation of MSBA	Single school focus	graduate
2015	(Gupta et al., 2015)	BI&A model curriculum guidelines across program types (undergraduate, MS, and MBA)	Lit., interviews, and surveys	Undergraduate and graduate
2015	(Henry & Venkatraman, 2015)	Identified a need for data analytics integration into business skill sets and curriculum designs. Provided a framework to design and teach data analytics skills.	Literature	Unspecified
2015	(Hilgers et al., 2015)	Recognition that traditional business and IT degrees lack important data and analytics skills. A mapping of BA skills to three newly courses is documented.	Single school focus	Undergraduate
2015	(Kang et al., 2015)	Four pillars of analytics; trace the skills and courses needed to support each pillar.	Single school focus	Graduate
2015	(Mamonov et al., 2015)	Present competency-based BA curriculum	6 institutions	Graduate
2015	(Mitri & Palocsay, 2015)	Explore two curricular: a BI/BA concentration in a typical IS major and a comprehensive, integrated BI/BA undergraduate major. Assess 2010 IS Model curriculum in relation to BI/BA content,	Literature	Undergraduate
2015	(Rodammer et al., 2015)	Document the redesign of business curriculum to meet the demand for BA skills development	Single school focus	Undergraduate
2015	(Schiller et al., 2015)	BA curriculum strategies and best practices.	Conf. panel, 2 universities	Graduate
2015	(Wilder & Ozgur, 2015)	BA undergraduate curriculum designed around five knowledge domains: PLC, DM, analytical techniques, deployment, and a functional area.	Literature, single university focus	Undergraduate
2014	(Gorman & Klimberg, 2014)	Early analytics program benchmarking focused on job outlook and academic response and curricula (programs, concentrations, certificate + graduate)	32 institutions offering BA programs	Undergraduate and graduate programs
2014	(Jacobi et al., 2014)	Formalized interdisciplinary Big Data Analytics (BDA) curriculum development process.	Literature	Undergraduate
2014	(Wixom et al., 2014)	Panel report describing the current state and best practices in BI and BA curricula. Focus on the emergence of Big Data and its implications.	96 universities + practitioners	Undergraduate and graduate
2013	(Warner, 2013)	Overview of the efforts made to develop a curriculum for business analytics that meets the needs of all MBA students	Single school focus, literature	Graduate
2012	(Chiang et al., 2012)	Evaluate the role of BI&A education in business schools, the challenges facing IS depts, IS curricula and program development in BI&A education.	8 schools	Undergraduate and graduate
2009	(Sircar, 2009)	BI importance in the leading business programs and a description of BI/BA minor curriculum	50 universities, single school	Undergraduate



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