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Current and Future Artificial Intelligence (AI) Curriculum in Business School: A Text Mining Analysis

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ABSTRACT

As artificial intelligence (AI) becomes one of the most important driving forces in industrial innovations, more business schools, mostly in graduate programs, are introducing AI in their curricula, particularly in information systems (IS) curricula. However, there appears to be a paucity of research on the AI curriculum. This study examines the current status of the AI curriculum in both undergraduate and graduate business schools and provides recommendations for future AI curriculum development. The study develops a technical competency model for AI curriculum based on both MSIS2016 - Global Competency Model for Graduate Degree Programs in Information Systems and IS2020 - A Competency Model for Undergraduate Programs in Information Systems and the AI technical competencies. Using text mining analysis, we collected and analyzed AI courses from the top 46 business schools at both undergraduate and graduate levels, ranked by US News in 2020. The findings indicate that machine learning is at the core of the AI curriculum in business, and most AI curricula are a hybrid of AI and data analytics. This acknowledges that the AI curriculum is still at its early stage, and business schools are closely adhering to the industrial development trend. The proposed technical competency model for AI curriculum can serve as a guideline for future AI curriculum development in business schools. We hope this study provides systematic insight into AI curriculum and offers recommendations for business education, in IS programs specifically.

Keywords: Artificial intelligence, Business analytics, Data analytics, Machine learning, Deep learning, Text mining

1. INTRODUCTION

Artificial intelligence (AI) is transforming every aspect of society at the individual, organizational, and societal levels (Brynjolfsson & McAfee, 2017). AI is more than a support tool for making decisions, designing and producing new products and services, and improving personal lives (Brynjolfsson & Mitchell, 2017). It is also changing the employment landscape by replacing existing jobs and creating new jobs (Brynjolfsson & Mitchell, 2017). AI has been one of the most disruptive innovations since the first computer was invented five decades ago, and it is becoming a game-changer in the business community. AI is widely used in almost every industry sector and across every business area (e.g., marketing, management, accounting, finance, supply chain management/operations management). In fighting COVID-19, organizations have been quick to apply machine learning in the areas of enhancing customer communications, tracking virus spreads, and stepping up research and treatment (World Economic Forum, 2020).

Although there are many definitions of AI, one of the most well-known defines AI as the study of how to give features of human intelligence like learning, perception, comprehension, and problem-solving capabilities to a machine (McCarthy et al., 2006). AI consists of computing algorithms and mathematical models implemented in software and hardware such as logical reasoning (e.g., modeling human logical reasoning),

knowledge-based systems (e.g., expert inferencing systems), probabilistic approaches (e.g., Bayesian network, fuzzy logic), evolutionary computation, optimization (e.g., genetic algorithm), neural networks, and deep learning.

Machine learning is a subset of AI that automatically performs tasks by imitating intelligent human behavior. Deep learning refers to specific machine learning algorithms, primarily an artificial neural network, with many layers and nodes (neurons) so it can learn and improve its intelligence from large amounts of data. Today, machine learning and deep learning have shown great potential for processing huge datasets and are becoming the most prevalent AI technologies.

To meet the industrial development and applications of AI, many business schools have introduced AI content, primarily viewing AI as a natural extension of data analytics and decision-making tools in their business analytics curricula (Davenport, 2018a). For example, some business schools introduce machine learning, neural networks, and automation in their accounting analytics, marketing analytics, or financial technology curricula. AI requires technical knowledge, such as mathematics, statistics, behavior science, and computer science, and business skills regarding management, ethics, problem-solving, etc. Therefore, business schools usually offer AI curricula at the graduate level (e.g., MBA, EMBA, master's, doctorate). The report of CC2020 indicates that "Although at the time of this writing no formal professionally endorsed AI

curriculum exists, a curricular recommendation in these areas has the potential to emerge in the next few years” (p. 31). With the rapid development and applications of AI in every aspect of our lives and business operations, IS educators and scholars must ask how AI will be included in IS programs and take on a great role in business curricula.

IS educators need to introduce fast-developing and highly demanded technologies to address organizational needs and be ready to prepare their students for a world in which winners effectively integrate AI with human intelligence (Topi, 2019). Employers are looking for skills, not courses of study, and degrees are just a proxy for content knowledge (Stine et al., 2019). IS students need to build their critical thinking skills and problem-solving capabilities with an understanding of the implications and outcomes of IT-enabled organizational transformation and IT solutions to business problems (Markus, 2017). To meet this need, IS educators should help students prepare for future careers with human-AI integrated business skills.

Although more business schools integrate AI in their IS and other business curricula (e.g., marketing analytics, financial analytics), our extensive literature review (including AIS eLibrary, Google Scholar, *Journal of Information Systems Education (JISE)*, *Information Systems Education Journal (ISEDJ)*, and others) reveals there is a lack of studies on AI curriculum in business education. There are many questions. For example, what is the current status of the AI curriculum in graduate and undergraduate business programs? What skills should students learn about AI if it is introduced in IS or other business curricula? How does the IS curriculum follow AI development trends in the industry? How do business schools tailor AI curricula to their distinctive educational contexts?

This study investigates the current status of the AI curriculum at both graduate and undergraduate levels in business schools. Two skills are required for AI applications in business: technical skills and managerial skills. As an initial research effort, this study only explores the technical skills in the AI curriculum. We propose a technical competency-based model for future AI curriculum development and recommend that business schools adopt AI curricula. This paper is organized as follows. We review the AI curriculum in business schools first, followed by the AI technical competency model development, research methodology, data analysis, and discussion of findings. Last, we conclude the paper with the limitations of the study and recommendations for future AI curriculum development.

2. LITERATURE REVIEW

While IS programs translate it to an analytics-focused discipline, AI is included in a new analytics category - autonomous analytics (Davenport & Harris, 2017; Urbaczewski & Keeling, 2019). AI operates not only as a decision-making tool as in previous eras, but also performs autonomous executions of business functions (Davenport, 2018a). IS scholars (e.g., Davenport, 2018b; Stine et al., 2019; Topi, 2019) envision AI as the future of business curricula, particularly IS curricula. For example, Stine et al. (2019) indicate that most business schools see changing business curricula to reflect the current and future reality of AI-augmented work as a necessary first step. Similarly, Davenport (2018b) claims that more master’s business programs will focus on specific analytical

methods and tools, particularly AI, although professional AI programs may be offered in schools of computer science and engineering.

Davenport (2018a) views AI as a natural evolutionary outgrowth of analytics. He defines four eras of analytical activity over the lifespan of business analytics. According to Davenport’s (2018a) evolutionary model of analytics, analytics 1.0 is the era of artisanal descriptive analytics, data management, and analysis and reporting tools for internal decision support. Analytics 2.0 is the era of big data analytics with powerful data management platforms (e.g., Hadoop) and innovative information platforms (e.g., Google, Facebook, LinkedIn), which leads analytics from internal decision support to a “data science” type of decision-making. Analytics 3.0 is the era of data economy analytics, in which even companies in traditional industries transform their business models and cultures to extensive use of big data and analytics. Analytics 4.0 is the era of artificial intelligence (AI) or cognitive technologies. In Analytics 4.0, AI and analytics are mutually inclusive and developed together, and AI is widely adopted. For example, about 20 - 30% of large companies used AI in 2016 (Davenport, 2018a). These four eras of analytics reflect today’s AI development and its roots in business. Companies can benefit from already established analytics capabilities and successfully develop and apply AI in the best and easiest path (Davenport, 2018a). Accordingly, AI as an analytics tool is naturally embedded in the data analytics curriculum in business schools.

AI is a special form of IT resources - a hybrid of IT artifacts and human capital (Plastino & Purdy, 2018). Davenport (2018b) indicates that the AI curriculum should provide students with four types of expertise: quantitative and statistical skills; data management skills, business knowledge and design skills; and relationship and communication skills. The first two areas of expertise are technical competencies, and the last two are business competencies. AI curriculum in business schools must find the right balance between business and technical competencies (Topi, 2019). That is, business competencies related to factors such as people, organizations, society, morality, and ethics are equally important. However, humans are decision-makers, AI is not.

Topi (2019) calls for a systematic collaboration with other computing disciplines in IS curriculum development to meet the latest technology and business developments. Even though it is unclear what the role of business schools will be in the wave of AI programs (Davenport, 2018b), IS educators must take critical responsibility and accountability for AI curriculum development in business schools. Davenport (2018b) indicates that “to my knowledge, no business schools in the U.S. have degree programs in AI. This is not surprising, given the paucity of faculty with expertise in AI” (p. 3). Similarly, Stine et al. (2019) find that most business schools see the importance of AI; however, very few have the resources to implement an AI curriculum. In addition, AI requires solid STEM competencies (e.g., mathematics, statistics, computer science). The need for these competencies makes it hard for business schools to develop an AI curriculum that fits into their students’ knowledge domains. Consequently, widespread adoption of AI is unlikely for most business schools in the near term. AI curriculum in business schools is still at its early stage.

3. AI COMPETENCY MODEL DEVELOPMENT

3.1 Information Systems (IS) Competencies

This study aims to find the current status and the potential development direction of AI curricula in undergraduate and graduate business programs. We build our research foundation upon the latest developed IS curriculum models – the MSIS2016 Competency Model (for graduate degree programs in IS) and the IS2020 Competency Model (for undergraduate degree programs in IS). MSIS2016 identifies nine IS competency areas. IS2020 recognizes nineteen competency areas, ten of which are required and nine of which are elective. MSIS2016 and IS2020 are highly linked to each other. The IS2020 competencies prepare students with the following prerequisite competencies for graduate study in MSIS2016: 1) Data, Information, and Content Management, 2) IT Infrastructure, and 3) Systems Development and Deployment (IS2020, 2020). IS2020 builds upon previous curriculum models: MSIS2016, IT2017, and CC2020. It not only aims to guide the core curriculum that should be presented, but it also offers flexibility for customization to meet local institutional needs (IS2020, 2020). IS2020 provides more areas (required and elective) than MSIS2016. Table 1 shows the comparison and match between MSIS2016 and IS2020.

In the MSIS2016 Model, the area of “Data, Information, and Content Management” covers the “competencies that enable graduates to be effective contributors in processes that improve the domain’s ability to achieve its goals using structured and unstructured data and information effectively” (Topi et al., 2017, p. 70). This competency area corresponds to one required area: “Data and Information Management,” and two elective areas: “Data and Business Analytics (incl. Data Mining, AI, BI)” and “Data and Information Visualization” in the IS2020 Model. We notice that IS2020 started including AI in the “Data and Business Analytics” competency, properly reflecting the industrial development trend. According to the IS2020 report, “IS2020 is grounded in the expected requirements of the industry and the needs and perspectives of organizations that employ IS graduates and is reflective of the input and support of other IS-related organizations.” (p. 7) This is consistent with Davenport’s (2018a) declaration that today’s business analytics are transforming from Analytics 3.0, a big data analytics era, to Analytics 4.0, AI-concentrated analytics.

A competency model is a framework that collects competencies such as skills, knowledge, and capabilities needed for successful job performance. Competency models have been widely used in business for defining and assessing individual competencies in organizations. In education, competency models are used for assessing student outcomes and identifying professional requirements (Lucas, 2020). Future curricular models in computing and IS programs will be competency models (e.g., Gervais, 2016; Topi et al., 2017; Waguespack et al., 2018). Topi (2019) calls for a new key competency: understanding technology-based solutions’ implications and potential consequences. Topi (2019) further indicates the driver to this is the increasing application of AI and a large volume of heterogeneous data often used in problem-solving. Therefore, a competency model will well reflect today’s industrial demands on AI knowledge and skills from IS graduates and can serve as a foundational framework for AI curriculum development.

IS2020 (undergraduate)	MSIS2016 (graduate)
Foundation of Information Systems (required)	
Digital Innovation (elective) Emerging Technologies (e.g., IoT blockchain) (elective)	Innovation, Organizational Change, and Entrepreneurship
IS Management and Strategy (required)	IS Strategy and Governance
IT Infrastructure (required)	IT Infrastructure
Data and Information Management (required) Data and Business Analytics (incl. Data Mining, AI, BI) (elective) Data and Information Visualization (elective)	Data, Information, and Content Management
<i>Included in Systems Analysis and Design, IT Infrastructure, IS Management and Strategy</i>	Enterprise Architecture
Project Management (required) Business Process Management (elective)	IS Management and Operations
Systems Analysis and Design (required) Application Development and Programming (required) IS Practicum (required) Object-Oriented Paradigm (elective) Web Development (elective) Mobile Development (elective) User Interface Design (elective)	Systems Development and Deployment
Secure Computing (required)	Business Continuity and Information Assurance
Ethics, Use, and Implications for Society (required)	Ethics, Impacts, and Sustainability

Table 1. IS2020 and MSIS2016 Competency Models

3.2 AI Technical Competency Model

Recently, Anton et al. (2020) identified several AI competencies from a quantitative content analysis on 9,247 job postings in AI across 60 countries. The identified AI competencies are categorized into two groups: technical competencies and managerial competencies (see Table 2). These competencies reflect today’s AI technologies and development trends. That is, AI is a data-driven mathematical/statistical algorithm implemented in computer software and hardware.

The technical competencies in Table 2 can be categorized or viewed in two groups. The first group includes the AI Producer, who invents, designs and develops new AI algorithms. This group consists of two techniques: AI algorithm and AI programming. The other group is the AI Consumer, which applies AI to solve business problems. This group consists of AI framework on which business users work. Table

3 shows the two groups: AI Producer and AI Consumer, classified from the AI competencies in Table 2.

Technical competencies	Managerial competencies
<ul style="list-style-type: none"> • knowledge in AI-associated technologies and algorithms (ML, deep learning, neural networks) • programming (Python, Scala, Java, web development) • AI frameworks and libraries (TensorFlow, Pytorch, Keras, Scikit-learn, Numpy, Caffe) • big data analytics frameworks (Spark, Hadoop) • STEM knowledge (mathematical and statistical knowledge, computer science) • development methodologies (Agile software development) • problem-solving (initiative/engagement) • data management 	<ul style="list-style-type: none"> • business management (client focus/orientation, decision making) • business acumen (business development, interdisciplinary knowledge) • people and social skills (collaboration, building trust, leadership) • communication (oral and written communication)

Table 2. AI competencies (Anton et al., 2020)

AI Producer		AI Consumer
<u>AI Algorithm:</u>	<u>AI programming:</u>	<u>AI framework:</u>
STEM knowledge (mathematical, statistical knowledge, computer science)	Programming (Python, Scala, Java, web development)	AI frameworks and libraries (TensorFlow, Pytorch, Keras, Scikit-learn, Numpy, Caffe) Big data analytics frameworks (Spark, Hadoop)

Table 3. Classification of AI competencies (Anton et al., 2020)

AI algorithm is a mathematical/statistical model or algorithm that simulates human intelligence, which is called artificial intelligence (AI). Examples of AI algorithms include regression models, component analyses, support vector machines, decision trees, fuzzy logic, Bayesian networks, genetic algorithms, etc. AI algorithms depend on STEM knowledge as identified by Anton et al. (2020). AI programming is the development of an AI algorithm in a computer language such as C++, Java, Python, R, etc. AI framework is a software platform on which business users apply implemented AI algorithm(s) to solve problems. AI framework also allows AI developers to design, develop, and test new AI algorithms. Examples of AI frameworks include TensorFlow, Pytorch, Keras, Scikit-learn, Numpy, Caffe, etc. Knowledge of big data analytics frameworks (e.g., Spark, Hadoop) is also

identified and listed as AI technical competency by Anton et al. (2020). This is because AI is a natural continuation and extension of data analytics (Davenport, 2018a). Today’s data analytics are becoming more AI-based data analytics (Davenport, 2018a).

AI algorithm, AI programming, and AI framework cover most AI technical competencies listed by Anton et al. (2020) except for “knowledge in AI-associated technologies and algorithms (machine learning, deep learning, neural networks)” in Table 2. “Knowledge in AI-associated technologies and algorithms” actually represents an AI model that uses specific AI algorithm(s) to solve certain problems such as pattern recognition, natural language processing, computer vision, etc. AI model is an integration of AI algorithm, AI programming, and AI framework. In other words, an AI model refers to specific AI solution(s) implemented with AI algorithm(s), developed in AI programming language(s), and deployed and applied on AI framework(s). AI models include machine learning, deep learning, neural networks, expert systems, etc.

According to the AI categories in Table 3, we propose the AI technical competency model in Figure 1, which can guide future AI curriculum development. This model includes two types of competencies: AI Producer (AI algorithm and AI programming) and AI Consumer (AI framework). As Figure 1 shows, the AI model is found where an AI algorithm, an AI programming, and an AI framework overlap each other. In this technical competency model, we consider the AI model as the core of AI technical competencies. Our literature review reveals that machine learning, including deep learning, is the most important and prevailing AI model. Machine learning is a family of AI algorithms, including deep learning, neural networks, etc.

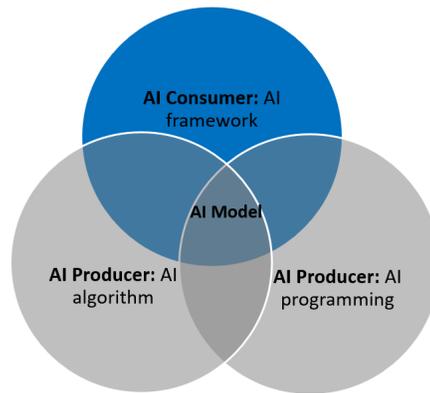


Figure 1. AI Technical Competency Model

In Figure 1, the AI model that integrates the AI algorithm, the AI programming, and the AI framework presents technical competencies that exist on the continuum between AI Producer and AI Consumer. The technical competencies represented by the AI model show us not only the AI solutions in business problem-solving but also future AI developments between AI Producer and AI Consumer. For example, machine learning as an AI model presents a class of AI algorithms and their implementations that use data to improve gradually their problem-solving performance. Machine learning has been applied to solve various business problems such as facial

recognition, language translation, medical diagnosis, predictive analytics, etc. Today, a new AI model, “augmented intelligence,” is emerging. Augmented intelligence partners people and AI to enhance cognitive performance such as learning, decision-making, and even new cognitive experiences. Once augmented intelligence is adopted in the business community, it becomes a new technical competency to be reflected in AI curricula.

We use the AI technical competency model in Figure 1 to conduct the data analysis in this study. In the following sections, we map the collected AI courses from both undergraduate and graduate programs into this model to discover what AI technical competencies are currently covered, and which the most prevailing AI technical competencies are offered in business schools. This competency model can also serve as a framework for identifying AI technical competencies in future AI curriculum development. For example, we can map the technical competencies required for IS graduates from the survey of industrial development into this model. According to the distributions (percentages) of the skills of AI Producer and AI Consumer, we can design and develop AI curricula to meet industrial demand.

4. RESEARCH METHODOLOGY

In this study, we use a direct survey method to collect sample AI courses for text mining analysis. The direct survey method uses available content online or in printed format (Stefanidis & Fitzgerald, 2014). The major advantage of this method is that researchers can focus on a specific study area, systematically collect data, and use standard data quantification (Kung et al., 2006). Many researchers have applied the direct survey method in IS curriculum studies (e.g., Aasheim et al., 2015; Kung et al., 2006; Lifer et al., 2009). We collected AI courses from websites and then conducted a text-mining analysis.

A wide range of methods and analytical techniques have been labeled as content analysis (Denzin & Lincoln, 1994; Miles & Huberman, 1994). The analysis of a text allows the researcher to understand the meanings of the content such as other people’s cognitive schemas (Gephart, 1993; Huff, 1990). Recently the text mining technique has been used in content analysis. Text mining analysis can be used for both quantitative and qualitative studies. Researchers can use text mining to extract explicit and implicit knowledge from large amounts of unstructured textual data (Debortoli et al., 2016).

We follow the guidelines for identifying the relevant literature and structuring the review proposed by Webster and Watson (2002) to conduct the text mining analysis. The research methodology is shown below in Figure 2.

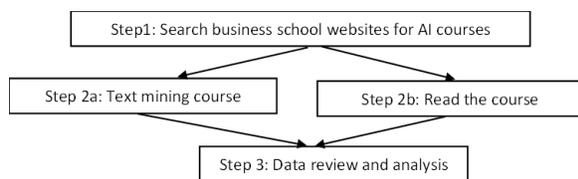


Figure 2. Research Methodology

We selected the undergraduate and graduate programs from the top 46 business schools ranked by U.S. News 2020 (Murray,

2020; see the Appendix). Of those schools, 50% are public, and 50% are private. These business schools represent the latest technology adoption in business education and reflect the business curriculum development in North America. In step 1, we searched each business school’s website and collected all courses related to AI into a text file. The collected courses are all offered in business schools and across different business programs such as IS, accounting, marketing, operation management, etc. No courses were retrieved from non-business programs, even though they also offer AI curricula.

In step 2, we conducted content analysis on the collected textual data using two approaches. First, we conducted the text mining analysis (Figure 2, Step 2a). There are various text mining methods. One of them is searching for predefined keywords and counting their frequencies in the unstructured textual content - a quantitative analysis. This counting-keywords method is called frequency analysis. At its most basic, frequency analysis has been considered an indicator of cognitive intention (Huff, 1990); groups of words reveal underlying themes, for example, co-occurrences of keywords can be interpreted as reflecting association among the underlying concepts (Duriu et al., 2007; Huff, 1990). The collected course descriptions from the public websites are very brief and only provide AI competency keywords as shown in Table 2. Therefore, frequency analysis is a valuable and feasible data analysis method for investigating the status of the AI curriculum, although it doesn’t provide in-depth looks or detailed insights. We developed a Windows application in C#, which searches for all the listed keywords in Table 2 in each course description file we collected from the 46 business schools’ websites. The software reads the keyword file, which stores the technical competency keywords found in Table 2 and all the course description files. It searches and counts the found keywords and writes their frequencies in a text file which can be imported into Excel for further analysis. We also asked a graduate research assistant with an AI research background to review each course description file again and gather AI technical competencies not listed in Table 2 (see Figure 2, Step 2b). So doing gave us more comprehensive coverage of the AI competencies covered by the business schools. Inter-rater reliability was not an issue in this quantitative analysis because we text-mined only pre-defined AI technical competency keywords, which do not require subjective interpretation. In the last step (Figure 2, Step 3), we conducted descriptive statistical analysis of the collected AI technical competencies. The findings are discussed next.

5. DISCUSSION OF THE FINDINGS

5.1 Data Analysis and Discussion

Table 4 lists AI technical competencies (Anton et al., 2020) obtained from the text mining analysis. Machine learning (31%) is the top technical competency offered in all AI curricula in both graduate and undergraduate programs. Deep learning as a specific machine learning model takes another 8%. Machine learning with deep learning counts for 39% of all AI curricula in both graduate and undergraduate programs. Machine learning, particularly deep learning, is the most important and promising AI technology continuously gaining steam in the industry. This finding not only indicates that business schools capture the industrial development trends but also supports that “machine learning is at the core of many approaches to artificial

intelligence, and is analytical (i.e., statistical) at its core” (Davenport, 2018a, p. 75).

Big data and data mining (20%) is ranked as the second most covered technical competency in AI curricula. This is understandable and reasonable. In the Evolution of Business Analytics Model, Davenport (2018a) indicates that AI is a natural continuation of business analytics; business schools usually extend their business analytics curricula with AI. Davenport (2018b) further claims that the AI curriculum is difficult to create, and most business schools are concentrating on analytics and data science instead. In industry, AI is still considered an advanced data analytics tool to help managers make decisions, although AI is constantly changing the business landscape. For example, AI automates business processes and decision-making, AI robots replace people’s jobs, etc. This finding indicates the current AI curriculum is a hybrid of data analytics.

Ranked as third and fourth are programming (17%) and STEM (math and statistics) (14%) competencies, respectively. AI is highly technical and requires people to have strong STEM competencies to understand, use, and develop AI models to solve business problems. An AI model is built upon mathematical algorithms, particularly on statistics, that are the core of machine learning (Davenport, 2018a), and developed in computer languages (e.g., Python, Java, C/C++). AI curricula require more STEM competencies than any traditional IS curricula do. However, adding more STEM content creates difficulties for graduate and undergraduate students, especially for undergraduates. Business schools must overcome this challenge in one way or another.

Technical competency	Undergrad (BBA, BS)	Graduate (MS, MBA, EMBA)	Number of Courses
Machine Learning	3 (2%)	40 (29%)	43 (31%)
Deep Learning	0 (0%)	11 (8%)	11 (8%)
Programming (Python, R, Java)	0 (0%)	23 (17%)	23 (17%)
Big data and data mining	2 (2%)	25 (18%)	27 (20%)
STEM: math and statistics	0 (0%)	20 (14%)	20 (14%)
AI frameworks and libraries	0 (0%)	6 (4%)	6 (4%)
Analytics frameworks	0 (0%)	8 (6%)	8 (6%)
Total	5 (4%)	133 (96%)	138 (100%)

Table 4. Technical Competencies from Text Mining Analysis

96% of the AI technical competencies are offered in graduate programs, and only 4% in undergraduate programs. All AI technical competencies in undergraduate programs are offered in IS programs which introduce the most important and basic AI (e.g., machine learning) concepts and applications in

their big data and data mining curricula. This finding indicates that undergraduate programs are far from adopting an AI curriculum. There are several potential explanations for this finding. First, AI is one of the most advanced technologies applied in decision-making and business process management, and automation. Teaching and learning AI usually requires business schools to have a high research capability and strong connections in the business community. Graduate programs are, thus, a good start to adopting an AI curriculum. Second, graduate students (e.g., MBA students) usually have higher STEM competencies and more business knowledge than undergraduate students, so it is more appropriate and easier for graduate students to learn AI and its business applications. Third, undergraduate students have tight class schedules in their four-year curriculum and lower STEM competencies. This limitation leads to difficulty in adopting AI curricula in undergraduate programs. We believe that with more AI curricula to be adopted in business schools, particularly graduate programs, the IS programs will lead the effort in this direction.

Besides the AI technical competencies identified by Anton et al. (2020), we also extracted more technical competencies from the human reading of the curriculum text. These additional technical competencies are not listed by Anton et al. (2020). We grouped them into four areas: AI models (e.g., robots, computer vision), AI frameworks (e.g., Google Cloud AI, Microsoft Azure Learning Studio, IBM Watson), analytics frameworks (e.g., NoSQL, MapReduce, KNIME, Hortonworks, Google Analytics), and analytics tools or software (e.g., Excel, Crystal Ball, Tableau, Adobe Illustrator, Crystal Report), as shown in Table 5. All four areas in Table 5 are offered in graduate programs; however, only analytics frameworks and analytics tools are offered in undergraduate programs. This finding indicates that undergraduate programs still focus on data analytics with analytics frameworks and tools, such as Excel, Tableau, Google Charts, Crystal Ball, etc. There is no standalone AI curriculum offered in undergraduate programs. Although graduate programs offer some important AI models (e.g., Robots, Computer Vision) and AI framework (e.g., Google Cloud AI, Microsoft Azure Learning Studio, IBM Watson), none of the undergraduate programs have them in their AI curricula. We also find that different schools or programs usually customize their AI curricula with different AI models, AI frameworks, analytics frameworks, or analytics tools to meet their student’s needs in the job market. For example, Stanford Graduate School of Business, Haas School of Business at UC Berkeley, and Harvard Business School introduced robots, computer vision, and natural language processing in their graduate AI curricula, respectively. These specific AI technologies reflect each school’s unique business context and distinguish them from one another.

In sum, Table 4 and Table 5 shed light on AI technical competencies in AI curricula and provide a clear picture of today’s AI curriculum development status in undergraduate and graduate business programs. The future AI curriculum development will likely continue the current development trend and direction. With more availability and application of big data, AI will become fundamental decision-making tools and create more business process automation in the future. Accordingly, business schools will follow the industrial development trend and introduce more AI in their curricula.

	Undergraduate (BBA, BS)	Graduate (MS, MBA, EMBA)
AI models: Autonomous Systems, Robots, Natural Language Processing (NLP), and Computer Vision	No	Yes
AI frameworks: DataRobot, RapidMiner, Keros, Pandas, AWS AI, Google Cloud AI, Microsoft Azure Learning Studio, IBM Watson, Weka	No	Yes
Analytics frameworks: NoSQL, MapReduce, KNIME, Hortonworks, Google Analytics, StatTools, Apache: Hadoop, Hive, Spark, Mahout, Sqoop, Impala, Pig	Yes	Yes
Analytics tools: Excel, Tableau, Many Eyes, Google Charts, Adobe Illustrator, Crystal Report, Crystal Ball, and Apache Zeppelin	Yes	Yes

Table 5. Technical competencies from human text reading

5.2 Discussion with the AI Technical Competency Model

Based on the results above, we now discuss the findings as they relate to the AI technical competency model, we proposed in Figure 1. We map the technical competencies in Table 4 into this competency model, and the results are shown in Figure 3. AI model (39%) includes “machine learning” (31%) and “deep learning” (8%). Deep learning is a specific machine learning model. AI algorithm is the “STEM: math and statistics” (14%). AI programming is “Programming (Python, R, Java)” (17%). AI framework is “AI frameworks and libraries” (4%).

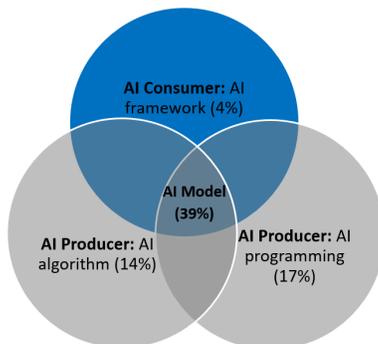


Figure 3. Findings with the AI Technical Competency Model

From the perspectives of AI Producers and AI Consumers, we see the AI Producer competencies take 31% of all the technical competencies in AI curricula, and the AI Consumer is only 4%. This percentage reflects that AI is highly technical and AI curricula in business schools have to cover enough fundamental science (e.g., STEM) and information technology (e.g., programming). This further confirmed Topi’s (2019) proposition that systematic collaboration with other computing disciplines is necessary for IS curriculum development to meet the latest technology developments. Today we are still in the so-called “weak” AI. Weak AI often refers to the fact that AI models can only perform a specific class of tasks such as facial recognition, language translation, etc. In contrast, “strong” AI is AI that can perform various tasks and can learn by itself to solve new problems like human intelligence. With weak AI, people usually have to design and develop new AI algorithms to solve new problems, and this needs more AI Producer competencies. There is no one-size-fits-all AI solution. However, the AI model (machine learning and deep learning) as an integration of AI Producer and AI Consumer takes the highest percentage (39%) of the entire technical competencies in AI curricula. This suggests that AI model, which is focused on AI’s business solutions, is what the business curriculum needs. In sum, AI framework, AI algorithm, AI programming, and AI model in Figure 3 together account for 74% of all the technical competencies in both graduate and undergraduate programs, in which the AI model (machine learning including deep learning) is the core of AI technologies (Davenport, 2018a). The remaining 26% are data analytics skills – “big data and data mining” and “analytics frameworks.” This acknowledges that the AI curriculum is still a hybrid of data analytics and a natural extension of data analytics (Davenport, 2018a).

With can better understand the AI curriculum structure and development status with the AI technical competency model. The data analysis with this model presents what AI technical competencies are required by industry and how they are covered in AI curricula. The AI technical competency model can act as a lens to detect future AI needs in the industry and reflect them in AI curriculum development. For example, with more AI automation (e.g., self-driving vehicles, accounting auditing automation, robotic inventory operation) being adopted, the corresponding technical competencies can be recognized and presented as a new AI model (e.g., automation, robotics) with its related AI algorithms in the AI technical competency model.

6. CONCLUSION

This study explores current AI curriculum development in undergraduate and graduate programs from 46 business schools. The findings indicate that AI curricula are well established in graduate programs, accounting for 96% of all AI curricula; however, AI curricula are underdeveloped in undergraduate programs, accounting for only 4%. In all the AI curricula at graduate and undergraduate levels, AI technical competencies account for 74% and data analytics makes up the remaining 26%. This percentage confirms that AI is a natural extension of data analytics (Davenport, 2018a), and data analytics applies to the AI curriculum by reducing involvement by human analysts (Urbaczewski & Keeling, 2019).

However, AI is largely different from traditional data analytics in terms of fundamental algorithms and implementation. It is necessary to develop a rigorous model for the rapidly growing AI curriculum adoption in business schools. As an initiative, this study proposes the AI technical competency model based on the MSIS2016 and IS2020 Competency Models. By mapping the AI technical competencies from 46 business schools at the graduate and undergraduate levels, we find that AI model, which includes machine learning and deep learning, is the core of AI curricula, primarily in graduate AI curricula. In addition, AI algorithms, AI programming, and AI framework are all covered in AI curricula, which support and implement AI model. We expect that the AI technical competency model will provide a guideline or tool for future AI curriculum development. We also hope the findings of this study provide meaningful insight into AI curriculum development in business schools.

6.1 Limitations

The study has several limitations that will provide opportunities for future research and education practices in AI curriculum development. Searching and retrieving course information on public websites usually lacks comprehensive or detailed information about the curriculum. Most course information posted online is a course description. Although a course description provides a brief, high-level overview, it is impossible to identify every topic covered within a course or how those topics are implemented (Aasheim et al., 2015). Most course descriptions we retrieved from the public websites only contain AI competency keywords and/or one or two-sentence descriptions about the course. Hence, besides the frequency analysis, we are not able to find more information about the competencies. Future research can survey faculty and students to obtain more comprehensive and detailed curriculum information such as content, tools, labs, projects, assignments, etc. With more detailed curriculum information, IS educators and scholars can conduct a more comprehensive content analysis in step 2 (a & b) in Figure 2. This includes multiple experts/analysts reviewing and double-checking the findings to reduce possible human errors to obtain a more accurate and comprehensive picture of the status of AI curricula.

This study examines AI curricula from 46 top-ranking business schools. These schools have strong research emphases and sufficient resources (e.g., funding, faculty recruitment, and research facilities). They also have good industry connections. These advantages help them more easily develop new curricula to reflect the latest technology and business developments. However, most business schools lack these advantages. Accordingly, the curriculum development in these top-ranking schools may not be duplicated for many teaching-focused business schools. To overcome this limitation, future research in AI curriculum development needs to examine more business schools ranging from teaching to research-focused. In addition, future research should also investigate schools' business contexts, such as educational resources, external business supports, and, in particular, graduate recruiters. Each school has its unique business setting, which distinguishes it from others in AI curriculum development.

This research is an exploratory study and only investigates the technical competencies. At this time, many business schools have not yet introduced AI in their IS programs although there is likely a considerable number of IS educators interested in this

area. IS2020 has little to say directly related to AI in IS curricula. With a lack of information about AI curricula offered in business schools, this study doesn't provide specific AI competencies needed in business schools nor answers certain critical questions, such as if AI should be introduced in business curricula at this time. Despite these limitations, this study exploits a new IS curriculum territory. It provides a benchmarking direction for future studies and development of AI curricula, especially as more graduate business programs are introducing AI curricula. AI is prevalent in most modern systems available today, particularly "for service organizations in public and private sectors, AI is expected to make dramatic advances." (IS2020, 2020, p. 24) We believe that further research on AI curricula in IS and other business programs is in high demand with the wide adoption of AI in various industrial sectors.

6.2 Recommendations

AI is becoming an important curriculum in IS and other business programs (e.g., marketing, operation management, finance). Stine et al. (2019) indicate that "Changing the business school curriculum to reflect the current and future reality of AI-augmented work is seen as a necessary first step for the majority of schools" (p. 5), and business majors need both theory and hands-on experience with AI. We make several recommendations below based on the findings of this study.

Graduate programs such as MS in IS, MBA, and EMBA are the first movers of AI curricula. Graduate programs can utilize their research capabilities to explore AI curriculum development and provide guidelines for entire business schools. Cross-curricular development is necessary. IS and computer science programs can develop joint AI curricula for both science and business majors with different emphases on technical competencies. IS and other business programs, such as marketing, can also offer cross-curricular AI with a focus on solutions to business problems. IS programs can act as a bridge connecting computer science to business disciplines through AI curricular development.

AI curriculum is underdeveloped in undergraduate programs. The major reason for this is that undergraduate students in business schools usually lack STEM and programming competencies. It is challenging to enhance these competencies in business schools since time-to-graduation constrains often bind liberal arts universities. To overcome this constraint, we suggest that undergraduate programs offer an AI certificate or minor, like a security certificate or minor in IS programs. An AI certificate can be initiated by IS programs and cross majors depending on the school's education setting and business environment, such as their surrounding job market. With the AI certificate or minor, undergraduate students can take more STEM and programming courses. Business schools can offer elective courses for AI once they adopt AI curricula. Indeed, a certain level of STEM competencies is necessary for AI curricula.

Besides offering the IS minor, certificate, and/or elective for AI, IS programs can be focused on specific AI models (e.g., deep learning) for certain business solutions (e.g., marketing analytics, accounting automation) with specific tools. For example, IS programs can use the IBM Watson Machine Learning tool to conduct data analytics in a business analytics class or an elective for AI. In their AI curricula, graduate and undergraduate IS classes can introduce AI tools, such as the

IBM Watson cloud. For the undergraduate IS major or data analytics-related majors (e.g., marketing analytics, financial technology), the AI curriculum can cover fundamental AI knowledge without getting into detailed AI algorithms or programming and teach students problem-solving skills with AI tools. We believe this is feasible and will be a good start for AI curricula in business education. Future IS programs may need more lab sessions in their curricula to keep pace with fast technological development and adoption in business.

We emphasize the role of IS programs in AI curriculum development. Urbaczewski & Keeling (2019) reviewed the history of IS program development and advocated for the transition from IS departments to analytics departments, in which AI would lead such change. The IS discipline bridges business and technology, offering a technical solution to a business problem. IS programs are the pioneers and leaders in AI curriculum development and adoption in business schools. IS programs should not only lead AI curriculum development to respond to industrial demands quickly, but also help business schools to innovate their curricula to prepare their students for future technology-driven business innovation and problem-solving. IS programs should distinguish their AI curricula to reflect their schools' unique education setting and surrounding job market, and address issues and challenges AI creates, such as ethics, security, social, and legal issues, etc.

Last, we emphasize that technical and managerial competencies are equally important in business curricula. Both technical and managerial competencies are required in the job market (Anton et al., 2020). Although this curriculum study only investigates the technical competencies, we hope to see more comprehensive research that investigates technical and managerial competencies from an integrative view. For example, ethics is a critical issue and consideration in AI application. AI has created many ethical concerns such as replacing human jobs, ethical decision-making from self-driving vehicles, autonomous weapons, and even apocalyptic fears as described in "The Terminator." AI usage requires managerial competencies, and its related implications and issues should be well reflected in future AI curricula.

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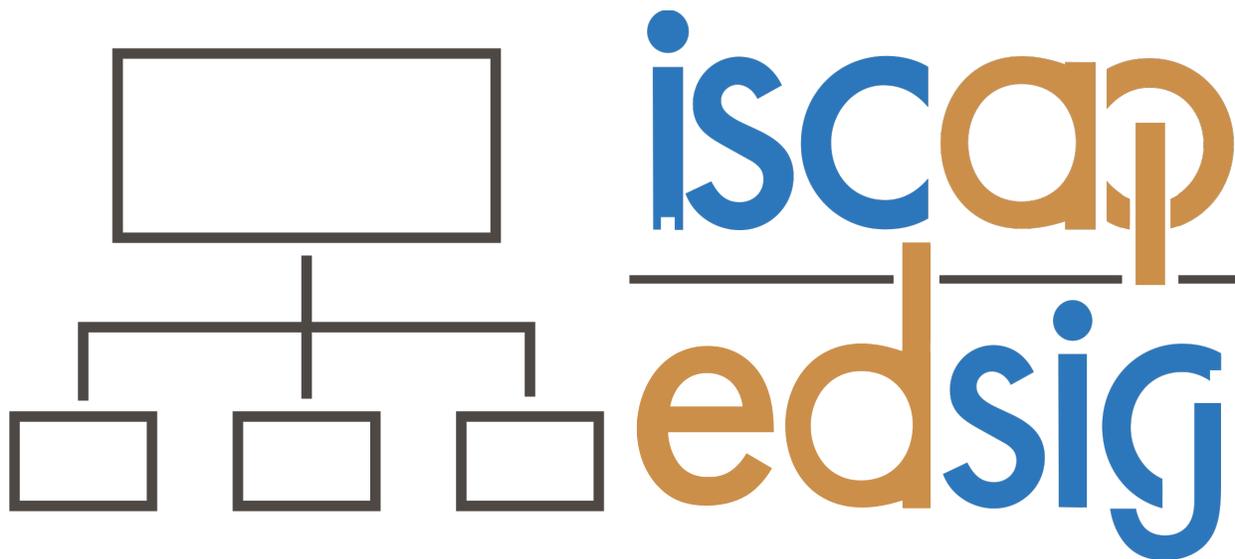
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APPENDIX

Top 46 Business Schools Ranked by U.S. News 2020 (Murray, 2020)

1. Stanford University (Graduate School of Business)
2. University of Pennsylvania (Wharton)
3. Northwestern University (Kellogg)
4. University of Chicago (Booth)
5. Massachusetts Institute of Technology (Sloan)
6. Harvard University (HBS)
7. University of California - Berkeley (Haas)
8. Columbia University (Columbia Business School)
9. Yale University (School of Management)
10. New York University (Stern)
11. University of Virginia (Darden)
12. Dartmouth College (Tuck)
13. Duke University (Fuqua)
14. University of Michigan - Ann Arbor (Ross)
15. Cornell University (Johnson)
16. University of California - Los Angeles (Anderson)
17. University of Southern California (Marshall)
18. University of Texas - Austin (McCombs)
19. Carnegie Mellon University (Tepper)
20. University of North Carolina - Chapel Hill (Kenan-Flagler)
21. University of Washington (Foster)
22. Emory University (Goizueta)
23. Indiana University (Kelley)
24. Vanderbilt University (Owen)
25. Georgetown University (McDonough)
26. Rice University (Jones)
27. Georgia Institute of Technology (Scheller)
28. University of Florida (Warrington)
29. University of Minnesota - Twin Cities (Carlson)
30. Brigham Young University (Marriott)
31. University of Notre Dame (Mendoza)
32. Washington University in St. Louis (Olin)
33. University of Georgia (Terry)
34. University of Texas-Dallas (Naveen Jindal School of Management)
35. Arizona State University (W.P. Carey)
36. University of Rochester (Simon)
37. Ohio State University (Fisher)
38. University of Wisconsin – Madison
39. University of Pittsburgh (Katz)
40. Michigan State University (Broad)
41. Pennsylvania State University - University Park (Smeal)
42. Southern Methodist University (Cox)
43. University of Alabama (Manderson)
44. Texas A&M University - College Station (Mays)
45. University of Maryland - College Park (Smith)
46. University of Arizona (Eller)



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