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Developing institutional skills for addressing big data: Experiences in implementation of AACSB Standard 5 ☆

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ABSTRACT

The explosion of data coupled with firms' desire to utilize it is driving rapid changes in the desired skillset for accounting and assurance professionals. Educational institutions are considering how to catch up to these requirements, while accreditors are also modifying standards to reflect changes in desired skillsets. We present evidence from two institutions' efforts to update their courses to address contemporary skill requirements, accompanied by discussion from a Big 4 professional. We find that despite significant differences between the two institutions and their approaches, similar challenges were encountered, and similar feedback was obtained from students. We conclude with a proposal for four basic tenets that we believe should be considered by any institution updating curriculum in response to Big Data and related analytics skills.

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1. Introduction

The adoption rate of Big Data efforts is one of the fastest tech-adoption phenomena in the business world (Malone, 2016). One byproduct of this rapid pace of adoption is the need for enhanced skills in the accounting and assurance professions (Borthick & Pennington, 2017; Dzuranin & Mălăescu, 2016). Gone are the days when the assurance or audit professional would primarily sample transactions from paper-based artifacts (Warren, Moffitt, & Byrnes, 2015); rather, professionals are expected to extract and analyze full populations from various applications, sometimes combining both internal and external data sources. This expectation of enhanced technical skills expands beyond assurance and audit to include all areas of accounting (Borthick & Pennington, 2017; Janvrin & Watson, 2017). For example, a recent article in *Strategic Finance* states that entry-level corporate accounting jobs no longer consist of significant clerical activities; instead, they are heavy on data skills (R. Lawson & Smith, 2018). In response to this, Dzuranin et al. (2018) suggest that universities should be producing graduates who are ready to extract value from data in order to address employer expectations.

Employer demands are rapidly changing, as described by the CFO of Tente Casters Inc., "A college grad telling me they know how to do debits and credits and financial statements doesn't really help me. . .. . ..What I need is someone who can analyze data, see problems and figure out solutions." (Johnson, 2015, p. 2). Professional service firms are also emphasiz-

☆ This article is based on a panel discussion, "Teaching Analytics in AIS—the Buzzword" at the SIGASYS Pre-ICIS Workshop in San Francisco, CA, December 2018. The authors of this article presented their case studies / perspectives in this forum which was followed by a very insightful discussion from other AIS educators. We thank the participants for their inputs.

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ing the need for enhanced analytics skills. A recent white paper published by PwC (2015) highlighted that "...at PwC, we believe data analytics should be integrated into accounting coursework." (p. 1) EY's *Future Work Now* program supports the same need, stating that "organizations need a more flexible, more digitally literate, and more innovative workforce than ever before." (EY, 2018). KPMG further reinforces this point by stating that "embracing the power of D&A (data and analytics) is essential to auditors performing our duties as stewards of the capital markets" (R. O'Donnell, 2016, p. 26). While some of these expectations may seem rather extreme, as employers would undoubtedly be upset if college graduates did not understand the basics of accounting, it nevertheless highlights a serious issue facing accounting pedagogy: the need to teach analytic skills in addition to accounting fundamentals.

In response to market demand and the Pathways Commission Report (AAA, 2012), the Association to Advance Collegiate Schools of Business (AACSB) modified its accreditation standards (AACSB, 2018) to update a specific standard (Standard A5 (previously labeled "Standard A7")) related to integration of information technology (IT) in the accounting curriculum. This standard focuses on the agility of both accounting graduates and accounting faculty in developing and maintaining the skills and knowledge of emerging trends in information technology (IT). Schools around the world, particularly in North America, are modifying their courses and/or curricula to meet this new demand. Responding to this changing environment, frameworks have been suggested based on surveys from educators and professionals to modify curriculum (Dzuranin et al., 2018; R. A. Lawson et al., 2014; R. A. Lawson et al., 2015; Pincus, Stout, Sorensen, Stocks, & Lawson, 2017; Sledgianowski, Gomaa, & Tan, 2017), and review of existing research (Qasim & Kharbat, 2019). However, there has been very little empirical research reported on actual implementation of curriculum to meet the suggested guidelines. Trying to meet the requirements of AACSB standard A5 is a challenge which is "...especially true for accounting programs that have separate AACSB accreditation, given that Accreditation Standard A7 (now A5)...requires universities with separate accounting accreditation to include content and learning objectives associated with data analytics and information technology skills in its curriculum" (Dzuranin et al., 2018, p. 24).

1.1. Need for graduates with updated skills

While universities are making changes at both the course and curriculum level, the needs of employers are changing much faster than the academy. Each of the largest accounting related professional associations are focused on these needs. In June 2019 NASBA and the AICPA issued a request for input on potential technology-driven updates to the CPA license model (Gonzalez, 2019) and in 2020 they established a website to solicit comments (NASBA & AICPA, 2020). On May 20, 2020 the AICPA Governing Council voted in favor of advancing this initiative and NASBA also approved the initiative in July 2020. At the 2019 Institute of Internal Auditors (IIA) International Conference attended by one of our panelists, a significant portion of the breakout sessions were technology centric. The Institute of Management Accountants (IMA) has established an online "technology and analytics center" to assist its membership in keeping up with trends in the finance and accounting professions.

To address these changes, the authors presented a panel discussion in December 2018 which we summarize as part of this paper. One author, a principal at a Big 4 accounting firm, noted that the graduates being produced today are not meeting the needs of the profession. He expressed the following "wish list" for institutions producing future new hires. This wish list was in response to comments made by the two faculty panelists and audience members. Further comments from the practitioner panelist are included in Section 3.3:

- **Technology Introduction:** Technology is often taught late in academic programs. Accounting Information Systems (AIS) and Management Information Systems (MIS) are sometimes integrated into programs only at the graduate level, which (in his opinion) is too late. Students should be exposed to data creation, management, analysis, and data wrangling skills much earlier, ideally in their freshman or sophomore years.
- **Digital Upskilling** In this fiercely competitive landscape firms emphasize the need to get the answers fast; graduates should be experts in using tools to their advantage to deliver results. (PwC, 2019).
- **Experienced Presenters:** People like to hear stories. Verbal and written communication skills are essential for success in the business world. Students should be trained in using visualization to tell a comprehensive story and should have extensive experience presenting prior to graduation.
- **Automation/System Appreciation:** A substantial amount of time in schools is spent on teaching core accounting skills. It is important to teach these basics and it is also important that students understand that routine accounting transactions are the most likely to be automated. Assessing and presenting the impact with "what-if" scenarios will be the skill level expected of future graduates.
- **Accreditation Modification:** The current accounting curriculum is constrained by the volume of instruction required to meet core accreditation requirements. Schools (or groups of schools) should potentially lobby the accreditation institutions to adjust requirements in alignment with industry demands. Partnering with private organizations (such as Big 4 professional service firms) to influence accreditation requirements might be a step in the right direction.
- **Resources without Borders:** One of the strongest challenges that university faculty face is the issue of keeping course content up to date with the pace of rapidly emerging technology. There is a vast amount of content that is readily available—evolving and more current than any textbook. Schools should take advantage of these resources to keep their

courses current. With the rapid pace of technology change, professionals will need to reskill and retrain within a few years after graduation to stay marketable in industry. Universities should consider opportunities to open their programs to this audience.

The principal concluded his comments with discussion of how "*The future is now*":

"As we take inventory of the skillsets that we are hiring, we are already behind in servicing the market demand. We are having to invest in significant retooling of graduates when they come off campus to get them abreast in the latest tools such as to push their technology knowledge further up as per client requirements, than what was expected of them on campus."

While the above wish list reflects the views of one principal from one firm, there is significant evidence that these are not isolated views. Review of practitioner literature and our interactions with other practitioners suggest his opinions are not unique. For example, on December 31, 2018, the IMA released a video attempting to answer the question "How do finance and accounting professionals stay relevant in a digital age?" (Institute of Management Accountants, 2018) Recent Global Knowledge Briefs from the IIA include titles such as "Approaches to Upskilling" and "Data Analytics Mandate."(Institute of Internal Auditors, 2019a, 2019b) KPMG's "Next Generation Audit" (KPMG, 2019) series with Forbes stresses technology related issues, and EY offers insight for clients and potential new hires into how they are preparing their auditors with additional technology (Zimmerman, 2019).

To address employers' needs for graduates with updated skills, Dzuranin et al. (2018) proposed three potential approaches for accounting schools to infuse technology into a schools' curricula:

Introduce a standalone course to teach technology (focused approach)
Integrate technology topics into existing courses (technology integration approach)
Take a hybrid approach and combine standalone courses as well as integrating analytics into the existing accounting curricula (hybrid approach)

Our research extends that of Dzuranin et al. (2018) by examining how two schools of accountancy have modified their accounting curriculum based on the above suggestions. This "*call to action*" also motivates our institutional discussion below to address our research question:

RQ: What are some examples of how existing accounting information systems and related courses can be adapted to prepare students with the knowledge and skills necessary to address employer needs as it relates to the Big Data revolution?

This paper contributes to accounting education literature by discussing two organizations' efforts to modify curricula to provide enhanced technology skills to graduates, coupled with commentary from a Big Four principal offered as part of a panel discussion that included an overview of these efforts. The two universities addressed curriculum modification in different ways. The first university used a focused approach to update a standalone course, while the second university used a hybrid approach to propose a new degree focusing on analytics. Finally, the professional service firm principal commented on these approaches; thus, this paper presents three disparate points of view.

This article is based on the model of a best practices paper (Jalbert, 2008) and is organized as follows: we first present a synopsis of existing literature identifying efforts in academia to incorporate data analytics into university curriculum. This is followed by best practices implemented in two schools as separate but comparable case studies, as one of the first attempts to provide examples of how the suggestions have been implemented: one is a smaller program at a public university with 130 + students in the accounting major, the other a private business university with a large accounting program (400 + under graduate accounting majors). We then add the remaining comments from our practitioner panelist and conclude with discussion, recommendations, and conclusions. Please note that these are only two examples showing modification of either a class or a degree program. Institutions with intentions to increase their analytics offerings could choose one of these approaches or introduce changes that best fit their program.

2. Literature review

2.1. Big data in accounting

With the adoption of technology in all spheres of business, data are being generated at an almost exponential rate (Cukier & Mayer-Schoenberger, 2013) which, in popular parlance, is called "Big Data"(Sledgianowski et al., 2017). According to industry reports "70% of firms now say that big data is of critical importance to their firms" (Malone, 2016); however, it is estimated that only 1% of the data available are effectively used by firm(s) to their advantage (Forbes, 2018).

The diagram below from the Ernst and Young Academic Resource Center (Fig. 1) conceptualizes the Big Data spectrum, starting from accounting transactions generated by sales and purchasing systems and extending outward from the organization to data generated by clickstreams on the web. Data analytics have progressed from analyzing structured data collected via enterprise systems (Appelbaum, Kogan, Vasarhelyi, & Yan, 2017) to also incorporate unstructured data from text, audio and video systems (Chen, Chiang, & Storey, 2012). Manifestation of "Big Data" in the accounting domain is changing the job description of accountants (R. Lawson & Smith, 2018; Sledgianowski et al., 2017). Accounting records have gone

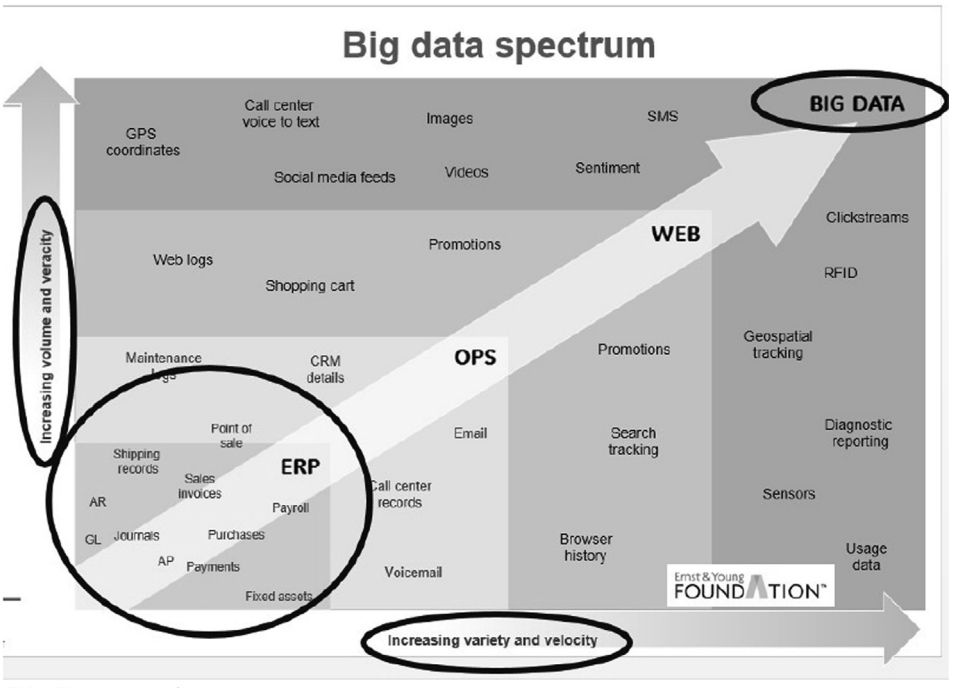

Fig. 1. Big Data spectrum.

from physical storage to an estimated 98 percent electronic record storage (Warren et al., 2015), with additional data being generated through various other channels [e.g. by sensor devices (IoT[1]) and communications between devices and applications]. The work of accountants and auditors is also changing to address these circumstances. It has been estimated that clerical accounting jobs, such as book-keeping and tax preparation, have a 98 percent chance of being automated, while other accountants' and auditors' jobs (up to 94 percent) are susceptible to the same automation efforts (Frey & Osborne, 2017). To be relevant in this digital world, the typical accountant must develop an analytical mindset to be able mine the available data, to derive business inferences, and to make actionable decisions. For example, staff auditors need the ability to identify issues relating to topics as diverse as manufacturing processes, employee productivity, customer satisfaction, fair value accounting, and audit efficiency and effectiveness rather than performing routine or repetitive transaction testing (Warren et al., 2015).

Unfortunately, research in data analytics, especially as it relates to accounting research (Qi & Vasarhelyi, 2014) and accounting education (Apostolou, Dorminey, Hassell, & Rebele, 2016), has trailed behind. Grimm and Blazovich (2016) stress that academia should make efforts to integrate professional competencies throughout the accounting curriculum. Among the professional competencies needing further research are "identifying the important cognitive skills required for accountants to conduct effective Big Data analysis" (McKinney, Yoos, & Snead, 2017) and decision making in this new environment (Ballou, Heitger, & Stoel, 2018). In the next section, we discuss research on the present state of literature on accounting education focusing on initiatives in the development of data analytic skills in students.

2.2. Accounting education

Rebele and St. Pierre (2015) report that most of the accounting educational research is non-empirical and that accounting education research is stagnated. They argue that "Researchers can make an important contribution to the accounting education literature by focusing on information systems, emphasizing what should be covered and how the coverage should be integrated into the accounting curriculum." (p. 135). Additionally, it has been claimed that accounting research is far from the reality of what practitioners want (Basu, 2012). While this is a rather harsh critique of the state of research, it nonetheless emphasizes that research in accounting education needs to broaden to topics relevant to industry. Dzuranin et al. (2017) provides a comprehensive review of skill requirements in accounting education, which include developing an analytical mindset, soft skills, and technology skills needed for the new data analytic environment. Accounting departments need to recognize current industry demands and accept that technology will dramatically change the skills required of an accounting graduate (Pincus et al., 2017).

[1] IoT = Internet of Things

One cause of stagnation of research in education might be that it is difficult to identify Big Data resources for research and course work (Janvrin & Watson, 2017). One approach might be to have professionals and educators interact and design courses jointly (Fogarty & Black, 2014) through academic and industry partnerships (Wygal, 2015), while also involving educators with professional experience to take more responsibility in imparting skills that are necessary in the industry (Boyle, Carpenter, Hermanson, & Mero, 2015). Another approach is to enhance the courses in the accounting department to include data analytic skills in the course curriculum.

Based on industry demand for accounting graduates acquiring the skills to take advantage of Big Data, the AACSB recently modified its standard (AACSB, 2018), calling for accounting curriculums to "....include learning experiences that develop skills and knowledge related to the integration of information technology in accounting and business. This includes the ability of both faculty and students to adapt to emerging technologies as well as the mastery of current technology" (p. 27, Standard A5). Consistent with this mission, the curriculum should focus on three primary components:

Information systems and business processes including data creation, data manipulation, data management, security, and storage.
Data analytics including, for example, statistical techniques, clustering, data management, modeling, analysis, text analysis, predictive analytics, learning systems, and/or visualization.
Developing information technology agility among students and faculty, recognizing the need for continual learning of new skills needed by accounting professionals.

In analyzing the AACSB accreditation standards, Janvrin and Weidenmier-Watson (2017) believe that "...accounting is where Big Data belong(s)" (p. 4) and as evidence state "accountants tried to make sense of large volumes of business data, whether it came from a paper-based system, an early/legacy computer-based system, or a highly technical, all-encompassing enterprise system" (p. 3). We concur with this conclusion while acknowledging the challenges of effective curriculum updates.

2.3. Active learning

Research has shown that technology-related courses have not been among the favorite courses for accounting students (Vatanasakdakul & Aoun, 2011) despite evidence that alumni have long found considerable value in these courses (Fordham, 2005). One of the main reasons cited for the unpopularity of technology courses is that students, most of whom lack relevant work experience, fail to see the relevance of technology to their future careers. This attitude, however, is changing based on alumni feedback to students in most schools. Additionally, students will find technology courses more interesting and gain a positive learning experience if the course work is based on an "active learning" approach which makes assignments hands-on and enjoyable (Diaz, 2016; Gainor, Bline, & Zheng, 2014; Riley & Ward, 2017). As employers increase their emphasis on the need for technology skills, students are appreciating the need for hands-on exposure to technology related skills before they graduate.

Critical thinking has also been identified as one of the necessary skills for accounting graduates. Critical thinking is defined as "an investigation whose purpose is to explore a situation, phenomenon, question, or problem to arrive at a hypothesis or conclusion about it that integrates all available information and that can therefore be convincingly justified."(Kurfiss, 1988) Active learning activities can support enhanced critical thinking capability and increase student engagement (Gainor et al., 2014; Riley & Ward, 2017). An area which evidences application of critical thinking is business process analysis, which can help students to gain a holistic understanding of how accounting transactions in the context of Big Data are generated. Students first need to understand and appreciate how transactional accounting data are generated in ERP and other applications by events in a business process (Porter, 2018). Unfortunately, Wells (2018) reports that most textbooks do not explain how "...accounting data is sourced from business processes within the wider information systems" (p. 47). One of the things that educators can do is to explain to students how data are captured, stored, and used for decision-making (Bradford, 2011). As discussed below, an active learning approach has been used at two different institutions to increase student understanding of where data come from, how data can be obtained, and how those data can be more effectively used.

In addition to understanding the origin of data, employers expect graduates to have quantitative hands-on skills (Ragland & Ramachandran, 2014), including the ability to extract and transform relevant data (Dzuranin et al., 2018) from applications for consolidation and analysis. Once data have been extracted and transformed, students need the skills to analyze the data.

Students can acquire these quantitative skills through "active learning," which has been proved to be one of the most efficient ways to achieve teaching effectiveness (Diaz, 2016; Gainor et al., 2014). Minimal accounting education literature has focused on this approach (Riley & Ward, 2017); the case studies described here contribute to the active learning literature by providing examples of how active learning is used at two institutions to enhance students' Big Data analytic-related skills.

Regardless of the approach, we argue that accounting pedagogy has four basic tenets:

1. Understand how to learn
2. Know how to communicate
3. Understand the need to pay attention to detail
4. Develop technology skills

The case studies below show how this approach was taken by two institutions to meet the employers' increased demands of technology and analytics skills from our graduates.

3. Case studies

As noted above, Dzuranin et al. (2018) proposed that there are three potential approaches for incorporating data analytics into the curriculum: 1) as a standalone course, 2) by integrating the topic in existing courses and 3) through a hybrid approach that combines a standalone course with integrating analytics in other courses as well. The case studies represent three disparate points of view: A large state university, a small private university, and a large accounting firm expressing their "wish list" as an employer. The smaller accounting program modified its standalone course, while the larger accounting program with over 20 years of technology focus adopted a unique hybrid approach during a time when the development of new courses was discouraged, by leveraging existing analytics resources in other university departments. The cases were presented at a panel discussion emphasizing both the different approaches and different needs of the participants.

3.1. Large state university/minimal systems emphasis/resources (focused approach)

SUNY-BU is a large public institution. The accounting department has a separate AACSB accreditation in addition to the AACSB accreditation for the School of Management and offers both undergraduate and graduate (MS) degrees in accounting. The MS degree in accounting is a five-year program with most students taking an extra year after their undergraduate degree to accumulate the 150 credit hours required for eligibility to become licensed as CPAs. SUNY-BU has only one technology-related course (AIS) in the MS Accounting program. Accounting graduates from SUNY-BU are typically hired by the Big 4 (PwC, EY, Deloitte and KPMG), as well as by firms such as Goldman Sachs, American Express, JPMorgan, Morgan Stanley, Bank of America, Citi, Grant Thornton, Protiviti, IBM, etc. SUNY-BU is the number-one provider of new hires for PwC and EY in New York City. Smaller local CPA firms and banks also hire SUNY-BU students. Although smaller firms and banks do not deal with the same high volumes of data as the bigger firms, they identified that the basic skills they look for in recruiting recent graduates are very similar. In a list of the most important skills that can be taught at school, the Vice President of a local bank notably identified "passionate ability to ask and answer questions in large datasets" and "communicate that interpretation to managers. . .."

3.1.1. Needs identification

Consistent with gaps identified in the literature review section, SUNY-BU identified the need to change the accounting course curriculum based on (1) feedback from the employers, (2) the changing AACSB accreditation guidelines based on the Pathways Commission report (2015), (3) the white paper from PwC (2015) which highlighted the skill requirements of future accounting graduates, and (4) making the course work interesting to increase course enrollment. In early 2015 a task force was formed to review the accounting course curriculum centered on the four above mentioned inputs. The two major findings were that the AIS course was (a) passive, mainly theoretical, and lecture-driven (i.e. the students had scant exposure to hands-on exposure of data creation, data manipulation or management, data analytics, visualization, etc.) and was also (b) an elective course in the MS degree program with low student registration.

3.1.2. Course redesign

To address these issues, the course was redesigned completely based on discussions with multiple partners from the Big 4 professional service firms (SUNY-BU alumni) who are a part of the advisory board for the school. Once the new course structure was ready, it was rolled out as an elective, and one year later was promoted to required course status for the MS Accounting degree. The redesigned course structure focused on (1) accommodating requirements as stated in the AACSB guidelines (2015) which incidentally aligned to the PwC white paper (2015), and (2) an "active learning" method of imparting course material to increase interest in the course.

In addition to fulfilling AACSB guidelines and PwC requirements, the learning objectives of this course were focused on providing students with "active-learning" exposure to (1) how data is ***generated*** in an accounting information system (2) how data is ***extracted*** from an accounting information system for analysis and auditing and (3) how data is ***analyzed*** to make business decisions using "critical thinking." Critical thinking has been one of the sought-after requirements in accounting (Aldhizer III, 2015; Spiceland, Spiceland, & Schaeffer, 2015) and business school (Athanassiou, McNett, & Harvey, 2003) curricula.

3.1.3. Planning

One of the major challenges for rolling out the newly designed course was the logistics of getting the hardware and software infrastructure in place. The first step was organizing access to an accounting information system. Choices included

applications such as Microsoft Dynamics[2], Quickbooks[3], and SAP[4]; SAP was selected as best suited to the needs of SUNY-BU. SAP is an Enterprise Resource Planning (ERP) application used by the majority of the Fortune 500 organizations worldwide to manage their inventory, manufacturing, financials, sales and distribution, etc., with an extensive range of functionality beyond accounting. However, in the context of this case study we consider SAP to be an accounting information system. SUNY-BU signed up for the SAP University Alliance Program, which allows student access to SAP. University investment for this is approximately $10,000 per year.

Next, an "active learning" environment needed to be organized where real-life scenarios could be simulated for generating accounting transactions. ERPsim[5] was selected since it is a business simulation game which runs on SAP, where students use the real SAP system to manage a virtual organization in a competitive market. Using ERPsim, the students in teams manage business processes which generate accounting transactions in the back end. The "active learning" environment allows students to appreciate transactions generated and understand decision making capabilities based on transactional data. Students must purchase individual licenses from the ERPsim website. This requirement is included in the syllabus such that the student is aware of the financial commitment at the start of the course. The simulation game that the students play is the Manufacturing Extended Game, which generates accounting transactions from the sales, purchasing and manufacturing cycles.

The final step was identification of an analytical tool that helps the students critically analyze the data generated. While there are several tools in the market such as Tableau[6], Spotfire[7], Qlik[8], and Microsoft BI[9], Tableau was selected because it is the most widely used and is relatively easy to use. A Tableau license for academic use is free for students.

3.1.4. Execution

The next stage was launching the newly redesigned course. The learning objectives were achieved using different tools at different phases in the course.

a. *Generation of accounting data*: Students were given an exercise (Sales Cycle in Global Bike Inc.[10]) to understand how to navigate in SAP screens and understand how accounting transactions are generated in SAP. This exercise was followed by the students playing the ERPsim simulation game generating real-life like accounting transactions in SAP.
b. *Extraction of accounting data*: Students were required to explain and demonstrate how the data that they generated while playing the ERPsim simulation game is extracted from the SAP database to an ACCESS database.
c. *Analysis of accounting data*: Given the data extract of transactions that have been generated, students are then asked to analyze the data using Tableau as a visual analytic tool. They are to prepare a project report analyzing the transactional data reflecting on decisions that they took in the game which could have been improved upon using critical thinking skills.

3.1.5. Feedback

Feedback is essential to measuring the success of a project. The initial roll-out of the revised course was done in Fall 2015, followed by seven more semesters. There are three kinds of feedback that we received on this project. First, other employers also appreciated the efforts that we took to incorporate their feedback, as is evident in the following remarks:

"It was particularly exciting to learn your class is going to have the opportunity to get some hands-on experience in SAP—it's going to be an incredible experience." – *PwC*
"Accounting Information Systems is certainly one of the most applicable courses on-campus to our practice and I certainly enjoyed the discussion with your students." – *EY*

Feedback from the AACSB accreditation review team was similarly positive:

"The MS program curriculum has been modified to include Accounting Information Systems as a required course. In this course, students develop a variety of IS related skills. Specifically, students develop skills to run business processes, e.g., *revenue cycle, expenditure cycle and conversion cycle, for a fictitious organization in an Enterprise Application (SAP). They learn analytic tools like Excel/Tableau for data visualization."*

And lastly, the feedback from students has been extremely encouraging:

"Hope this email finds you well. Just dropping a note to let you know that your SAP lessons in the Accounting Information System class is very valuable. I am currently taking a course in auditing SAP system, and I believe it might be useful to be added to

[2] https://dynamics.microsoft.com/en-us/academic/
[3] https://www.intuit.com/partners/education-program/
[4] https://www.sap.com/training-certification/university-alliances.html
[5] https://erpsim.hec.ca/en/erpsim
[6] https://www.tableau.com/academic
[7] https://www.tibco.com/products/tibco-spotfire
[8] https://www.qlik.com/us/company/academic-program
[9] https://blogs.msdn.microsoft.com/education/2015/11/26/using-power-bi-for-education-analytics-in-schools/
[10] Available via SAP University Alliance Program

curriculum. SAP is a very complex system, and I have so much to learn. Thank you for introducing me this ERP system." – *consultant, Deloitte, US*

"I took your class Accounting Information System in the last semester of my graduate study and it is one of my favorite classes at BU. I've already graduated this summer and I'm currently working at China as an advisory consultant. I always wanted to say thank you for such an enjoyable class which opened my mind to data analytics. And those skills do help me sometimes at work :)" – *consultant, Deloitte, China*

3.1.6. Roadblocks and challenges

There were many roadblocks and challenges as we went through the process of creating this new class. While these challenges were difficult, we were able to address them. The challenges we faced were as follows:

a. Shortage of faculty with necessary skills: There has been a constant nationwide shortage of faculty to teach technology heavy courses in accounting like AIS, IT audit etc. (J. O'Donnell & Moore, 2005). The school recruited and lost two AIS faculty in two consecutive years, demonstrating the demand for AIS faculty. This resulted in a setback to design and modification of courses in the accounting program to address the market demand for data analytic skills, and to prepare for the AACSB Continuous Improvement Review. Ultimately an MIS department faculty member who had previously taught AIS at another school was requested to teach the AIS course.
b. Lack of training to upskill existing faculty on analytical IT tools. The decreased costs of acquiring IT infrastructure, and the introduction of innovative Big Data tools and applications in recent years have resulted in difficulties with faculty staying current with this technological revolution. Designing courses with experiential learning on these new tools and techniques was challenging; however, the Accounting department budgeted for and sent faculty to conferences and workshops that provided hands-on experience on analytical tools.
c. Learning new analytic tools can be difficult and complex and takes time: Faculty took the initiative to allocate time between semesters to attend workshops and learn tools like Tableau.
d. Lack of incentives for faculty to upskill: Most tenured and tenure track faculty were not motivated to upskill themselves in newer technology in addition to their other responsibilities. Hence, redesigning courses to incorporate data analytics tools was difficult. However, as past students started to highlight the need for graduates to have basic analytic skills, faculty became more aware that they need to expose students to technology and analytic skills in courses, and most of the accounting faculty started to incorporate analytics into course curricula.
e. Dependency of teaching analytics in a single AIS course: The school had no AIS course at the undergraduate level, there was only one AIS course in the MS Accounting program at the graduate level, with one faculty member teaching the AIS course. Incorporating theory and tools into the single course, to cover a vast topic like data analytics was extremely difficult. It was subsequently decided that tools like Tableau would be covered in the mandatory prerequisite Introduction to IS course so that all business school students will get an exposure to visualization tools although not focused on accounting data per se.

3.1.7. Lessons learned

During this implementation, we learned many things that facilitated our efforts. The major lessons include:

a. Be open to feedback from employers, AACSB accreditation review teams, alumni, students, and colleagues.
b. Be ready to adjust the course structure as you start implementation. There will be challenges that cannot be anticipated before the roll-out begins. For example, in the first semester of the roll-out there were two SAP exercises (Sales Cycle and Purchasing Cycle). However, the feedback from students was that the work was time consuming and the second exercise was not adding much value. Beginning the next semester, the second exercise was dropped.
c. The instructor needs to attend the SAP University Alliance Faculty and ERPsim workshops to get structured training on the software.
d. Hire TAs that have attended your course in the past or have used SAP in their work before to support students.

3.2. Small private university/heavy systems emphasis (hybrid approach)

Bentley University is a private business university with AACSB accreditation at the university level and, separately, at the department level for accountancy. Bentley's department of accountancy has made a concerted effort over the past 20 years to require accounting information systems (AIS) as a critical component in all accounting-related degrees. Further, Bentley is undergoing considerable efforts to include data analytics in classes at both the undergraduate and graduate level. Bentley University's Department of Accountancy offers three undergraduate and two graduate degree options in accountancy. Bentley accounting graduates are typically employed by all of the major accounting firms (Big 4 in addition to Grant Thornton, RSM, BDO, etc.) and other firms in the technology, finance, banking, insurance, biopharmaceutical and manufacturing sectors. Bentley University graduates are hired to work in locations throughout the United States and abroad.

3.2.1. Needs identification

In the early 2000 s, consistent with direction from Bentley University leadership and noticing the gaps identified in the literature review section, the Department of Accountancy took steps to redesign their program to incorporate technology at all levels of the curriculum and to provide degrees based on feedback from employers, in particular the Big Four professional service firms and major corporate internal audit functions. Change was also driven by the 150-hour requirement to sit for the CPA exam and the department's efforts to accommodate individuals who were looking to obtain a graduate degree in accountancy. The undergraduate degrees separated into three paths: The pure accountancy path (Accounting), the corporate finance path (Corporate Finance & Accounting), and the systems path (Information Systems Audit & Control). The specifics of the undergraduate degrees in accountancy offered at Bentley are discussed in detail in Appendix A. All of the Accountancy related undergraduate degrees require students to take an AIS class. In addition, all Bentley students learn to use SAP in a required business processes and systems course.

As graduate students come from diverse backgrounds and may not have the same technology exposure as Bentley undergraduates, it became evident that the single graduate degree in accountancy, while sufficient to qualify individuals to obtain the course requirements and credits to sit for the CPA exam, was not meeting the needs of many Bentley undergraduate students wanting to obtain a graduate degree. Further, the changing AACSB accreditation guidelines based on the Pathways Commission report (2015) emphasized need for change, as did increasing demand for a degree option which would provide additional Optional Practical Training (OPT) opportunities for international students.

3.2.2. Planning

In 2017 a special committee was formed, which developed a proposal for a Masters in Accounting Analytics program. The major obstacle impacting this effort was a requirement by the administration to use only existing University courses with course modification. The proposal was approved, and the program was soft launched in the fall of 2018. Efforts are ongoing to expand data analytics education and awareness at the undergraduate level as well through updates to existing courses.

3.2.3. Execution

The new Master of Science in Accounting Analytics (MSAA) was soft-launched Fall 2018 and is STEM designated. The MSAA is the primary focus of the data analytics effort of the department.[11] Students admitted to this program are evaluated for potential waiver of six foundation courses, one of which is the graduate AIS course, to ensure students have necessary foundational knowledge. As part of the university's analytics core, all analytics students are required to take classes on data management and Structured Query Language (SQL) (offered by the university's Computer Science Department), a data visualization course (offered by the university's Information and Process Management (IPM) department), and a quantitative analysis course (offered by the university's Statistics department).

Additional required coursework for MSAA students includes Advanced AIS, IT auditing, Financial Modeling (offered by the university's Finance Department), Data Science (Offered by the Math Department), and Intermediate Statistical Modeling (offered by the Statistics Department). These courses, complemented by other electives with embedded analytics (see Table 1 for course offering list showing required (R) and elective (E) courses) from the Accountancy, Computer Science, IPM, and Statistics departments as well as available analytics-related internships, allow the students to focus on skills that will prepare them for analytics-focused jobs upon completion of their degree.

Faculty teaching in the MSAA program and the analytics core share syllabi and communicate with each other to discuss learning objectives and course materials. As shown below under lessons learned, it was quickly realized that additional coordination was necessary; therefore, committees were formed to facilitate additional communication among faculty.

At the graduate level, there is a heavy reliance on cases and projects as part of the pedagogical efforts. Extract-Transform-Load (ETL), data query, database design techniques, data visualization, and role-based access control are integral parts of the required coursework. Most accounting classes require a strong knowledge of Excel starting in the introductory accounting classes. Other classes include the use of software such as Access (database), Tableau, Alteryx, Python, and IDEA. The capstone course will add Robotics Processing Automation tool UiPath and potentially other tools as well.

3.2.4. Feedback

The graduate IT Audit class is one of the required classes for the MSAA. In this class, a modified version of the Ernst & Young Academic Resource Center (EYARC[12]) procurement card case is used as an active learning assignment to give students experience with audit planning basics and the ETL process along with querying data and presenting results. Students must use Excel, Access, and Tableau as part of this project and also explore Alteryx, Python, and IDEA use. They must establish data controls to ensure no data is lost or modified while moving between software tools and to check the reasonableness of query results. The software applications are not taught as part of the class; students must leverage their existing skills, research skills, and skills of their group members to complete the project. Student feedback has been encouraging. For example, these are graduate student comments from the fall 2018 reflection assignment:

[11] The Masters in Accountancy degree is focused on individuals with no accounting background and can be classified as a "Traditional" accountancy masters degree fulfilling the audit, accounting, tax, etc. requirements necessary to qualify to sit for the CPA exam in the United States.

[12] For information on EYARC see https://www.ey.com/Publication/vwLUAssets/EY_Academic_Resource_Center/$FILE/EYARC-brochure.pdf

Table 1
Accounting courses for masters degrees.

Courses[a]	MSA	MSAA
Pre-requisites		
Undergraduate degree in accountancy[b]		R
General accountancy courses		
Financial accounting problems 1	R	
Financial accounting problems 2	R	
Cost accounting	R	
Federal income taxation	R	
Financial statement auditing	R	
Professional accounting research & policy	R	E
Accountancy systems-type courses		
Accounting information systems	R	
Advanced accounting information systems	E	R
IT Audit	E	R
Enterprise systems configuration for business	E	E
Accounting analytics in practice		E[c]
Analytics practice internship		E
Specialized accountancy courses		
Accounting practice internship	E	
Accounting for income taxes	E	
Advanced topics in financial accounting	E	
Business reporting & analysis	E	
Fraud & forensic accounting	E	E
Governmental accounting, reporting & auditing	E	
Internal audit	E	
International accounting	E	
Principles of fraud investigation	E	E
Tax factors in business decisions	E	
Courses outside the accounting department		
Data management and sql for analytics		R
Data science		R
Financial modeling		R
Intermediate statistical modeling for business		R
Managing with analytics		R
Quantitative analysis for business		R
Business intelligence methods & technologies		E
Data management architectures		E
Information security, control, & ethics		E
Object oriented application development		E

[a] Bolded Accounting courses offer data analytics exercises/cases/training as part of the curriculum.
[b] For the MSAA, students either must have an accounting undergraduate degree from Bentley University or an equivalent degree from another institution.
[c] This new capstone course will launch in Academic Year 2020–2021 and will eventually be a required course.

"I was actually able to make immediate use of skills practiced in the process. In an interview for a corporate finance position, I was asked about a situation where I was analyzing data and had to focus on small details; I actually described my work on this project. I found it to be a great illustration of analytical experience during my recent interview. I wish more projects in academia were as relevant to the real world as this one was."
"This past summer I interned at a small public accounting firm, and I learned more through this project than I did the entire summer as an audit intern. I actually analyzed data through this project."
"Despite the project being rigorous and challenging, I am glad that I was given the opportunity to work through it because I learned different hard and soft skills while working on the project."
"I just find it fascinating how many things are possible in excel and how no matter how comfortable I feel using it, there is always something else to learn. I feel confident that I have learned both hard and soft skills from this project that I will be able to use later in my future career."
"This part of the project also gave me insights of how Access and similar programs can be used to audit and monitor data. Another step in this part of the project was to take one of the queries and turn it into a visual graph by using Tableau. I thought this was an important part of the project because in my experience the senior management and the audit committee are more interested in visualizations of the key findings as opposed to the granular details in work papers."

While these anecdotal comments are generally positive, they also mirror the survey results from Spring 2019 shown in the Discussion and Conclusions section below.

3.2.5. Roadblocks and challenges

As with any curriculum update, Bentley has faced roadblocks and challenges in implementing its data analytics efforts. The initial formation of the MSAA degree was constrained by an administrative requirement that no new courses be created. This was addressed by modifying some of the existing accountancy courses shown in Table 1 to incorporate data analytics cases, projects, and/or topics into the existing course. Further, as part of an overall shift toward data analytics, the computer science department, finance department, information process and management (IPM) department, and math and statistics departments have tailored courses that reflect data analytics applicable to students in all analytics majors, including accounting.

Bentley also faced some of the challenges faced by SUNY-BU, notably:

a. Lack of training to upskill existing faculty on analytical IT tools. Designing courses with experiential learning on these new tools and techniques was challenging; however, Accounting department faculty were able to take advantage of firm sponsored conferences and local workshops that provided hands-on experience on analytical tools.
b. Learning new analytic tools can be difficult and complex and takes time: Faculty spend considerable time participating in webinars and local workshops and user group meetings to learn tools like Tableau and Alteryx.

There were also some challenges unique to a larger scale program:

a. Because of the multi-course, cross-departmental nature of the program it quickly became apparent that more coordination was needed. The Department of Accountancy has a long-standing Audit/AIS Curriculum Committee, and this group began including discussion of analytics related activities at each meeting. In addition, ad-hoc faculty user groups have formed to address challenges with common software across departments (Tableau in particular).
b. As new software was implemented in the classroom, with multiple on campus labs and classroom desktops, software license management quickly became a challenge. The academic technology center took over licensing for common cross-departmental applications (e.g., Tableau) and works with departments on their department specific applications (e.g., IDEA, Alteryx).
c. Student computers also proved to be challenging, as many graduate students choose to use the Macintosh operating system, while some programs such as IDEA and Alteryx do not have Mac versions. In addition, many student computers are underpowered for working with large datasets. Software was made available in labs, but many students prefer to work off campus. Bentley University has a virtual environment that was not set up for the volume of users or file sizes required for these programs. Efforts are ongoing to upgrade the cloud-based infrastructure to support these programs.
d. Obtaining quality data sets and cases for use in courses without duplicating projects was another early challenge. Bentley is developing a library of cases and datasets available from multiple sources, including professional service firms, accounting education journals, and online analytics resources such as the University of Arkansas[13], the HUB of Analytics Education[14], Kaggle[15], and governmental data sets[16]. Faculty members edit cases where allowed to tailor them to specific classes, and also author their own smaller cases.
e. Some students have grown accustomed to receiving step-by-step instructions for course projects involving technology. To encourage students in developing a growth mindset and the confidence to approach unfamiliar software, Bentley faculty are developing a curated library that includes video and text resources available from sources which are available to every Bentley student, including LinkedIn Learning, YouTube, software vendors, and SkillSoft.
f. Student workers in the various laboratories are often learning the software programs at the same time as the students they are there to assist, and faculty skills are sometimes less than those of the more advanced students as firms are now providing advanced tool training to student interns.

3.2.6. Lessons learned

As with all tasks, when we have challenges, we have the opportunity to learn from those issues. Similar to the SUNY-BU experience, we learned many things during this ongoing effort.

a. Be open to feedback from employers, AACSB accreditation review teams, alumni, students, and colleagues.
b. Be open to collaboration with others – other departments in your university, other universities, user groups, employers, software vendors, and professional associations.
c. Make incremental improvements to courses. For example, after five semesters, the IT audit course projects continue to be updated to improve student learning. Waiting until a project is 'perfect' results in lost learning opportunities.
d. Faculty buy-in is critical. Consistently communicate the message that analytics and technology are here to stay and need to be part of every course. Encourage faculty to take advantage of opportunities to learn about new technologies.

[13] https://walton.uark.edu/enterprise/exercises-usecases-labs/index.php
[14] https://www.hubae.org/
[15] https://www.kaggle.com/datasets
[16] https://data.boston.gov/

e. The availability of online resources changes with each semester. Be prepared with alternatives should a data set or other online tool disappear, or a software vendor changes their licensing practices.

3.3. Employer insights

PwC[17] is one of the biggest employers for both SUNY–BU and Bentley University accounting graduates. The panelist was included because of his expertise to comment on the approaches taken by the two universities to incorporate data analytics. He had previously guest lectured at SUNY-BU, and emphasized the need for technology knowledge, inquisitiveness, and the need for institutions to prepare the workforce of the future.

3.3.1. Change is here

The pace of change will never be as slow as it is today. Global megatrends (PwC, 2018) are pushing the pace of change to never-before-seen levels. While true that no matter how complex transactions get, a debit and credit was made somewhere, today's accounting graduates need to know more than this. Artificial Intelligence (AI) and Robotic Process Automation (RPA) will affect every level of the business and its people. Organizations can't protect jobs which are made redundant by technology; but they do have a responsibility to protect people by nurturing agility and adaptability through re-skilling. Developing depth of understanding and keen insight into the changing technology landscape is a must.

Graduates around the globe need to be prepared to work and live in a world where change and uncertainty are ever-present. These changes are taking place at a time when unprecedented risks, disruption, and political and societal upheaval are ever-present. Availability of the right mix of skill sets and talent is scarce and competition for the right talent is fierce. 'Talent' no longer means the same thing that it did ten years ago. For example, jobs such as data scientist, interface designer, and chief listening officer did not exist then (Martin, 2018). Many of the skillsets required tomorrow are for roles and job titles that are unknown today.

3.3.2. Getting ready for the future.

The PwC of the future is unlikely to be filled with only CPAs. We could reasonably foresee a future where the routine or repetitive accounting tasks are replaced by AI or RPA. Imagine a future where the judgment required to come to the correct accounting or tax conclusions is made by AI. The accountant will need the expert knowledge of the subject area and the domain knowledge of machine learning to validate and verify the automated decision. Diversity of skillsets, thought leaders, and an open mindset will be critical to secure success in this profession. As Carol Stubbings, Global Leader, People and Organization, PwC summarizes, "The secret for a bright future seems to me to lie in flexibility and in the ability to reinvent yourself. . .Think about yourself as a bundle of skills and capabilities, not a defined role or profession." Today's academic institutions need to develop a different type of graduate with the following traits:

- Be a "digital native"—able to work with today's technology and learn new technologies.
- Have exceptional project management skills—to make the complex appear simple and drive team success.
- Be an expert in data wrangling—comfortable with large scale data, ambiguity and the unknown.
- Have exceptional story telling skills—the proven ability to convey messages using story telling
- Be agile and adaptable to change—launch and iterate is the new model; need to be nimble of thought.
- Be a global citizen—exposed to global issues and able to navigate a virtual world without borders.

These traits are ***in addition*** to the traditional training in accounting, finance, taxation, information systems, computer science, etc., which has been the cornerstone of success in the past.

The educators of today need to partner with the profession to reimagine the future, building graduates capable of operating in this new paradigm. We can see a future where the auditor of tomorrow will spend most of their day developing, configuring, and deploying audit BOTS[18] to execute testing. We can see a future where data inside and outside organizations will be used in the audit in addition to the financial statements (e.g. what could Yelp ratings or Twitter posts tell you about a company's ability to be classified as a going concern?). In a real-time world, is the profession doing enough to provide real time assurance? Could there be a future where the annual and quarterly financial statements move to a more real-time model, where investors will demand real-time assurance and real-time auditing?

3.4. Student feedback statistics

To gauge the perceived effectiveness of the schools' efforts, we surveyed students at both institutions at the end of the Spring 2019 semester. Surveys were given using a paper survey at SUNY-BU and surveyed through Qualtrics at Bentley University. Students were offered bonus points for either completing the survey or an alternative activity requiring equal

[17] http://www.pwc.com
[18] A software robot device using AI

Table 2
Evaluation of analytics related learning objectives by class.

Scale: 0 = Disagree – 10 = Agree Mean (Standard Deviation)	SUNY-BU	Bentley University		
	Single course N = 58	Class 1 N = 29	Class 2 N = 33	Class 3 N = 27
1. This course helped me understand how transactional data are **created** by events in the business process.	8.62 (1.25)	9.45 (1.06)	7.91 (2.16)	6.30 (2.60)
2. This course helped me understand how **controls** are built into systems to maximize the quality and integrity of data in the system	8.55 (1.44)	8.66 (1.495)	8.85 (1.89)	6.56 (2.68)
3. This course helped me understand how transactional data are **extracted** from information systems.	8.21 (1.48)	9.28 (1.032)	8.97 (1.85)	6.15 (2.74)
4. This course helped me understand how transactional data are **transformed** after extraction in order to make analysis possible.	8.21 (1.23)	8.86 (1.382)	9.15 (1.48)	7.00 (2.47)
5. This course improved my understanding of how to **analyze** a large dataset.	7.97 (1.65)	7.55 (1.975)	9.06 (1.68)	7.89 (1.81)
6. This course helped me understand how transactional data can be analyzed using **visualization techniques**.	8.48 (1.89)	7.62 (2.908)	8.94 (1.46)	8.56 (1.60)
7. This course helped me understand how transactional data can be analyzed using **advanced statistical techniques**.	7.28 (1.86)	6.17 (3.241)	7.85 (2.35)	7.26 (2.21)
8. This course helped me understand that I will need to **continually update my technical skills** to be successful in my career.	9.14 (1.25)	9.21 (1.634)	9.24 (1.42)	8.78 (1.74)
9. I feel course project(s) was/were a **valuable educational experience**.	8.34 (1.64)	9.62 (0.728)	8.91 (2.13)	8.67 (1.44)

time and effort, and the data were collected under informed consent. Survey results are given below in Table 2. The results indicate that students perceive that both approaches satisfy the learning objectives of the courses.

Analysis of the data revealed that the approaches taken at both institutions were perceived by the students to be effective; while there are still many opportunities for improvement. Student comments were also solicited in each survey. Many students throughout the courses voiced concern about the amount of time required to complete projects or the number of projects; however, they found the projects themselves valuable. Tableau in particular was frequently mentioned as a tool they enjoyed learning.

The results from the single (more comprehensive) course at SUNY-BU has more consistent high marks in almost all of the learning objectives, while at Bentley University, each class has different learning objectives and projects. Therefore, variation between the two institutions and classes and between the three Bentley classes is to be expected. For example, in Class 1 there is a systems design project. Class 2 has a project involving data transformation and analysis. Class 3 was a fraud class that uses visualization to examine data to search for fraud. Consequently, each class showed more consistent high marks in the course-specific objectives, but lower marks in areas that were not heavily emphasized.

Finally, we used univariate testing (Churyk, Reinstein, & Smith, 2016) to see whether students' answers in each class differed significantly from a neutral response (Likert Median Value = 5). As shown below in Table 3, the median test indicate that with one exception (Objective 7, Bentley University Class 1) all of the student answers differ significantly (significance level of at least $p < 0.05$) from a neutral value (Median = 5), suggesting that students feel that they achieved the specified class objectives. The single exception was in a class where students were not exposed to any advanced statistics as part of the class.

4. Discussion and conclusions

This study addresses the lack of discussion of education technology or technology education in accounting programs (Rebele & St. Pierre, 2015) by providing evidence from two institutions' efforts aimed toward increasing data analytics coverage in the accounting curriculum. Dzuranin et al. (2018) proposed three potential approaches (focused approach with a standalone course, technology integration into existing courses, hybrid approach where standalone courses and technology integration are done concurrently). One institution is using the focused approach, while the other is using a hybrid approach. Our study differs from prior studies in that it is based on empirical data (examples based on actual programs).

The student feedback statistics indicate that both approaches were valuable for the students. Both institutions have recently completed AACSB continuous improvement reviews and have been re-accredited, demonstrating that both schools meet the minimum requirements of introducing technology to accountancy students (AACSB, 2018). However, as the practitioner panelist noted, we can do more to provide employers with students who are conversant in both technology and accounting knowledge. The purpose of this study is to highlight efforts made by two institutions to integrate "Big Data" into the accounting curricula.

To address this research question, we provided an overview of each institution's efforts showing the needs identification process, planning and execution of the necessary changes, initial anecdotal feedback, challenges faced, and lessons learned by each institution in its implementation efforts. We also received feedback from a practitioner regarding the need for these

Table 3
Course objective median tests.

Scale: 0 = Disagree – 10 = Agree Median Standardized Test Statistic*	SUNY-BU	Bentley University		
	Single course N = 58	Class 1 N = 29	Class 2 N = 33	Class 3 N = 27
1. This course helped me understand how transactional data are **created** by events in the business process.	8.00 6.78 ***	10.00 4.93***	8.50 4.34	6.00 2.40*
2. This course helped me understand how **controls** are built into systems to maximize the quality and integrity of data in the system	8.00 6.74***	9.00 4.68***	9.50 4.68***	6.00 2.13*
3. This course helped me understand how transactional data are **extracted** from information systems.	8.00 6.71***	10.00 4.81***	10.00 4.73***	6.00 2.18*
4. This course helped me understand how transactional data are **transformed** after extraction in order to make analysis possible.	8.00 6.84***	9.00 4.69***	10.00 4.87***	7.00 2.88**
5. This course improved my understanding of how to **analyze** a large dataset.	8.00 6.59***	8.00 4.04***	10.00 4.83***	8.00 3.87***
6. This course helped me understand how transactional data can be analyzed using **visualization techniques**.	8.00 6.38***	8.00 3.34**	9.00 4.80***	9.00 4.05***
7. This course helped me understand how transactional data can be analyzed using **advanced statistical techniques**.	8.00 5.96***	7.00 1.76 (ns)	9.00 4.07***	7.00 3.28**
8. This course helped me understand that I will need to **continually update my technical skills** to be successful in my career.	10.00 6.87***	10.00 4.81***	10.00 4.90***	10.00 4.00***
9. I feel course project(s) was/were a **valuable educational experience**.	8.00 6.65***	10.00 4.94***	10.00 4.65***	9.00 4.06***

***p < 0.001
**p < 0.01
*p < 0.05

efforts, and the need to go even further and faster than our institutions have done. These insights should provide guidelines to accounting program administrators and faculty, which they should consider when deciding the type of approach that may be best for their institutions. These guidelines will help in identifying how existing courses and programs can be adapted to meet the current and future needs of employers. It should be noted that both examples discussed above represent only two approaches to implementing AACSB Standard A5 and addressing the Big Data revolution. The possible approaches of other institutions looking to modify their programs can use these examples or pick an approach (focused, integration, hybrid (Dzuranin et al., 2018)) that best serves the needs and culture of their institution. Employers are desperate for graduates with data analytics skills. Any effort on the part of accounting educators helps the profession by producing more qualified graduates.

4.1. Limitations

Our study is subject to several limitations. Specifically, factors such as the student population and the availability of area employers to act as industry advisors impact the generalizability of this research to other institutions. Our conclusions are based on the progress reported by our institutions as of the survey date. However, with the rapid change in technology and employer requirements, the specific examples reported within this paper may become outdated. We believe that many of the lessons learned by our institutions are generalizable and will remain useful despite these limitations.

More research is needed to build on this discussion and the scope of this work (approaches used; lessons learned) by incorporating experiences from other institutions. Future research can utilize this qualitative data as a basis for course and program design, and to communicate with practitioners to more effectively meet the needs of those who hire our students.

The need to address the growing demand for analytical skills in university graduates has never been more urgent than it is today. First-year accounting graduates are expected to know not only an accounting curriculum, but also how to leverage ever-changing technology so they are able to address the explosion of data that businesses generate on a day-to-day basis. The Big 4′s challenge for universities to be nimble enough to address these issues may be difficult to meet given the traditionally slow pace of academia, but we believe it is possible for the institutions to focus on a set of basics that will enable their students to be successful in the current and future workplace.

4.2. Concluding remarks

The technology taught at the university will likely be obsolete by the time a student enters the workforce but, as noted earlier, the basics or fundamentals of accounting education remain. Therefore, students must:

Table A1
Accounting courses for Bentley undergraduate accounting degrees.[a]

Accounting	Corporate finance & accounting	Information systems audit & control
Cost management	Cost management	Enterprise systems configuration
Financial accounting and reporting 1 & 2	Financial accounting and reporting 1 & 2	Financial accounting and reporting 1 & 2
Accounting information systems	Principles of accounting and finance	**Accounting information systems**
Financial statement auditing or internal auditing	International finance	**Financial statement auditing or internal auditing**
Federal taxation	Performance management and evaluation	**IT auditing**
	Managerial communication	**Advanced accounting information systems**
		Information security and computer forensics
*Accounting electives	*Accounting or finance electives	*Accounting or systems electives

[a] Bolded courses offer data analytics exercises/cases/training as part of the curriculum.

1. Understand how to learn: We need to teach students that "learning to learn" and "inquisitiveness" will make them invaluable to their employers. This will require students to realize that there is not always one right answer in the workplace, and that it may be a significant amount of time before they know if their 'answer' is correct.
2. Know how to communicate: Both verbal and written communication skills are essential in any career. Visualization and utilization of visualization software is a skill that is now part of the communications suite required by employers. Knowing how to make an effective presentation, how to develop a well-thought-out memo/letter/proposal, and how to present complex data and analytical results in a simple manner are all skills that will drive future success.
3. Understand the need to pay attention to detail: Through high expectations and requiring attention to detail at every level in accounting courses, the student who can produce (relatively) error-free programs, automations, spreadsheets, presentations, etc. is a prize for any employer. These workers can be trusted to do more complex tasks because they have demonstrated their mastery of the basics.
4. Develop technology skills: Students need to understand that the excuse "I don't do well with computers" is no longer valid in the current environment. Employers expect graduates to be digital natives. Universities need to include technology from the first day of class and reward innovative use of technology.

The first three items above are basic skills that should be taught regardless of the era. Indeed, it is those who know the value of inquisitiveness, can attend to the details of a project, and then communicate the results of that project who fuel innovation in all areas of business and science. The AACSB (Standard A5), though outdated in the minds of many business professionals, is a good requirement for schools seeking accreditation. Technology skills can be emphasized early (#4 above), with use expanded throughout the university experience (#1–3). In this way, even if our students lack the specific technology skills needed for a particular job, they will have the ability to quickly adapt to ever-changing requirements. We believe these basic skills must be considered as part of any attempt to address data analytics in the accounting curriculum.

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Appendix A. . Undergraduate degrees

The undergraduate degrees include the Accountancy major (targeted at CPA track students looking to enter the workforce at an accounting firm, Big 4, etc.), a Corporate Finance and Accounting (CFA) major (targeted at students looking to work in corporate accounting functions), and an Information Systems Audit and Control (ISAC) major (targeted at individuals looking to focus on controls and control auditing). There are typically more than 500 undergraduate students enrolled in accounting-related majors at any given time.

All of the undergraduate degrees require the basic AIS course as a pre-requisite to taking one of the introductory auditing (financial, internal) courses offered by the department. In addition, advanced AIS, IT auditing, forensic auditing, information security, and ERP configuration courses are either required or elective courses depending on the major enrolled (Table A1 below lists specific accounting courses with bold titles emphasizing IT). All Bentley undergraduates are required to complete the general business (GB) core, which in addition to introductory accounting and finance also includes courses that introduce software applications such as Microsoft Excel and SAP. Furthermore, the AIS course includes an active learning project on mapping business processes for local firms as well as SAP assignments, audit courses include instruction on data analytics, and data analytics tools such as IDEA and advanced Microsoft Excel functionality that are common in practice. Analytical software skills are required to complete many individual and group level projects in accounting undergraduate courses.

All of these efforts focus to varying degrees on analyzing large data sets to achieve both classroom and industry objectives. Further, the ISAC major is Science, Technology, Engineering and Math (STEM) designated by the US Department of Education's Classification of Instructional Program (CIP) taxonomy, and the Department of Homeland Security (DHS) which allows an additional 24 months of OPT for international students.

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