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INFORMATION SYSTEMS EDUCATION JOURNAL

A Pedagogic Experience in Designing a Healthcare Analytics Course: Lessons Learned

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Abstract

This study presents a contextual active learning perspective on how a healthcare data analytics course was designed and delivered to students enrolled in a graduate business analytics degree. Industry and academia emphasizes the need to integrate context-specific learning, however contextual analytics courses are not widely offered in business schools. This course's pedagogical approach seeks to address this need by embracing a contextual active approach. Such approach is based on the following key components: (1) Active learning – designing each module of the course to include activities and lessons to promote active participation of learners, (2) contextual development – modules are developed using healthcare as the focus and context for all activities, (3) online adaptation – the course is delivered online in an unsynchronized mode and therefore the development adapts to online delivery intended to maximize learning. This course integrates a collaborative project with a healthcare industry partner where students analyze anonymized dataset for the purpose of a more contextual and experiential healthcare experience.

Keywords: Healthcare analytics, analytics, active learning, contextual active learning, pedagogical experience.

1. INTRODUCTION

Hospitals, insurance companies, and vendors are all competing for a limited pool of talented data analytics experts in healthcare (Bresnick 2019). This growing demand for healthcare data scientists is also highlighted in a recent study published by a premier journal – *Journal of the American Medical Informatics* – which calls for more training and education of skilled professionals to appropriately analyze healthcare data to improve care, predict epidemics, and reduce preventable deaths (Meyer 2019). As such, data analytics is becoming crucial in the evolution of healthcare practices and research (Belle et al. 2015).

Healthcare analytics can provide different stakeholders the ability to improve care delivery, disease exploration, patient engagement functionalities, financial efficiency, and operational effectiveness (Lin et al. 2017; Raghupathi and Raghupathi 2014). With healthcare organizations becoming more data driven, health associations, such as the American Health Information Management Association, are calling for professionals to effectively analyze data, interpret insights and identify the best methods to deliver high quality care (AHIMA 2017).

Developing the appropriate material can potentially strengthen the skills needed by the next-generation of healthcare analytic experts. However, curricular material as well as pedagogical research are not widely available in business analytics programs. Moreover, despite current studies advocating the importance of context when promoting active learning (Berkhout et al. 2018; Chung 2017), research on the development and delivery using contextual and active learning approaches is not widely available (Chung 2015).

To address this void of contextualized analytics, we developed a healthcare analytics course to interconnect analytics skills with domain knowledge and decision-making. In this course, we integrate a contextual active learning approach based upon the active learning principles and contextual course components for the purpose of developing curricular modules. A curricular module is an organized collection of objectives, activities, assignments and discussion spanning over a week (See Appendix A).

In the following sections, we present a brief exposition of the healthcare analytics and active learning pedagogy. Next, we discuss our experience with teaching this course, and present the pedagogy, approach, course content, and software application tools. We also describe different course assignments and exercises to support a contextual active learning approach. We conclude with a discussion of lessons learned and survey scores for the associated course learning outcomes.

2. RELATED WORK

Overview of Healthcare Analytics

Healthcare analytics refers to the use of tools (statistical, contextual, quantitative, predictive, etc.) for the purpose of providing actionable items for better decision making (Kankanhalli et al. 2016). Healthcare analytics can provide organizations the ability to use their data to improve quality of care, increase financial efficiency and operational effectiveness (Raghupathi and Raghupathi 2014). The domain offers a panoramic view of the healthcare data and thus provides different stakeholders the ability to go beyond improving profits and reducing waste, to enable epidemic predictions, disease mitigation and cure, and quality of life improvements (Lin et al. 2017).

Raghupathi and Raghupathi (2013) describe healthcare analytics through a four-stage model. The first stage, *descriptive analytics*, consists of categorizing and aggregating the data in order to understand past and current health care decisions. In healthcare, descriptive analytics is useful in answering questions such as: How many patients were treated? Which type of medical conditions were predominant? And what was the revenue generated by facility last quarter? *Predictive analytics* include "empirical methods (statistical and other) that generate data predictions as well as methods for assessing predictive power" (Shmueli and Koppius 2011, p. 553). In other words, it examines historical health data, detects patterns and then extrapolates these relationships to predict future outcomes. In predictive analytics, a health professional might seek to predict the type of patients who will respond to a given drug, patients who are most likely to have a medical condition (e.g., heart attack), anticipated costs, or predict medication failures. Unlike descriptive analytics, predictive analytics uses more advanced techniques and methods, such as data mining. The third stage of analytics is *prescriptive*. It uses medical and healthcare knowledge to supplement the outcomes of descriptive and predictive analytics to finalize a decision when more than one choice is available. Finally, *discovery analytics* utilizes "knowledge about knowledge, or wisdom, to discover new drugs (drug discovery), previously unknown diseases, alternative treatments" (Raghupathi and Raghupathi 2013, p. 4). It is worth noting that while the tools and methods are different in descriptive, predictive, prescriptive, and discovery analytics, many applications involve all four approaches.

Contextual Active Learning Approach

Traditional lecture format or lecturing has been the principal method of teaching dating back to 900 years ago when universities were founded in Western Europe (Brockliss 1996). The traditional format has been labelled as a passive methodology because students simply receive information from the instructor (Pinder 2013). Active learning, often contrasted to the traditional lecture format, has been defined as methods and activities where students engage in the learning process through problem solving and higher-order thinking (Prince 2004). In other words, active learning promotes "instructional activities involving students in doing things and thinking about what they are doing" (Bonwell and Eison 1991, p. 3). The active learning approach has received considerable attention and its effectiveness has been supported in diverse domains, including software development (Roussev and Rousseva 2004), operation management (Hill and Baker 2016), marketing (Laverie 2006), and engineering (Prince 2004).

Despite current studies advocating the importance of context when promoting active learning (Berkhout et al. 2018; Chung 2017), research on the development and delivery using contextual and active learning approaches is not widely available (Chung 2015). Our pedagogical approach seeks to address this need.

3. PEDAGOGIC APPROACH, TOOLS, AND LEARNING GOALS

Course Learning Objectives

This course was offered online for graduate students majoring in business analytics and includes the following learning objectives (LO):

1. Define data sources and key uses for healthcare analytics (LO1).
2. Compare analytical methods and tools used to analyze healthcare data (LO2).
3. Apply analytical methods and tools to solve selected healthcare problems (LO3).

While the course has a statistics pre-requisite, most students already had taken other quantitative courses, including predictive analytics and data mining, which are required courses in the business analytics program. Therefore, the context of healthcare is the most attractive feature of this course where the focus is on solving problems and/or creating value for healthcare professionals. This course integrates a collaborative project with a healthcare industry partner where students analyze an anonymized dataset for the purpose of a more experiential healthcare experience. The integrative nature of this collaboration between industry and education not only allows students to analyze and interpret a real data set and problems, but also aligns students' analytical skills with the industry hiring needs and recruitment.

Seven Curricular Modules

In this section, we present the course curricular modules in a format that aligns with the contextual active learning approach introduced above. A curricular module is an organized collection of objectives, activities, assignments and discussion. Each module's objectives are aligned with the overall course learning objectives. To illustrate contextualization and active learning, each module also includes other components such as discussions, learning analytics tools, and engaging in an industry analytics project.

Module 1: Analytics in Healthcare

- Module Objectives:
  - Summarize the current state of data analytics in healthcare (LO1)
  - Classify types of Data Sources in Healthcare (LO1)
- Module Discussion:
  Discuss an example of a healthcare organization in using healthcare analytics to save lives, reduce cost, increase profit or other competitive advantages (LO1)
- Data Analytics Tools:
  Register for IBM Watson Analytics Account (LO3)

Module 2: Healthcare Data sources and Basic Analytics

- Module Objectives:
  - Examine Electronic Healthcare Records (LO1)
  - Compare biomedical image data sources and analysis (LO1)
  - Examine sensor data used in medical informatics (LO1)
  - Discuss types of biomedical signals (LO3)
- Module Discussion:
  Discuss the type of healthcare dataset(s) used in healthcare (LO1)
- Descriptive Analytics:
  Analyze healthcare security breaches using Watson analytics (LO3)

Module 3: Clinical Text and Social Media Data in Healthcare Analytics

- Module Objectives:
  - Analyze the role of Natural Language Processing (NLP) in healthcare (LO2)
  - Examine social media and analysis for healthcare analytics (LO2)
- Module Discussion:
  Locate a pertinent healthcare dataset and then analyze it (LO3)
- Data Visualization:
  Analyze a dataset of interest (deeper look into descriptive analytics) (LO3)

Module 4: Healthcare Analytics Tools and Methods

- Module Objectives:
  - Examine clinical prediction models (LO2)
  - Categorize temporal data mining for healthcare data (LO2)
  - Discuss visual analytics for healthcare (LO2)
- Module Discussion:
  Engage in critical thinking activities related to term project (LO3)
- Industry Term Project:
  Engage in descriptive analytics of the term project data (LO3)

Module 5: Applications of Healthcare Analytics

- Module Objectives:
  - Examine data analytics for fraud detection in healthcare (LO1)
  - Discuss data analytics for pharmaceutical discoveries (LO1)
- Module Discussion:
  Communicate in writing your descriptive and predictive and analytics findings (LO3)
- Industry Term Project:

Engage in predictive analytics by using IBM Watson Analytics to find top drivers and other factors (LO3)

Module 6: Challenges of Healthcare Analytics
- Module Objectives:
  - Discuss privacy and security issues related to healthcare analytics (LO1)
  - Compare privacy preserving publishing methods (LO2)
- Module Discussion:
  Discuss concerns/challenges (e.g., ethical, legal, data governance, silos, privacy, security...) as a result of the adoption of big data in healthcare (LO1)
- Industry driven Term Project:
  Analyze healthcare data using healthcare analytics techniques (beyond descriptive and predictive into prescriptive analytics) (LO3)

Module 7: Healthcare Analytics – What's Next
- Module Objectives:
  - Discuss career opportunities in healthcare analytics (LO1)
  - Examine trends in healthcare analytics (LO1)
  - Assess understanding of key concepts related to healthcare analytics (LO1, LO2, LO3)
- Module Discussion:
  Discuss career opportunities in healthcare analytics (LO1)
- Industry Driven Term Project:
  Communicate results and deliver final report with all the required sections

Platform and Analytic Techniques Overview

The big data analytic platform employs a plethora of techniques and tools to handle the large amount of data. Recent studies have shown that students are discouraged when multiple platforms are used within a single analytics course. Although it increases their breadth of software use, it decreases the depth of acquired skills within each application (Asamoah et al. 2017). As such, we embraced one major tool for this course to allow in-depth mastery of the skills leveraged through the tool.

The choice of tools, skills and content was based on feedback from industry and academia experts. Since advanced statistical methods are taught and used in other courses in the business analytics program, a focus on the contextual - Healthcare Analytics - was emphasized rather than learning a major new and or complex analytics technique. We selected IBM Watson Analytics as our data analytics tool for the following reasons: It allows users to 1) execute both descriptive and predictive analytics, 2) create dashboards and infographics, 3) discover relationships and test correlations, and 4) is cloud based and therefore has no/limited hardware constraints (https://www.ibm.com/watson-analytics). Figure 1 provides an illustration of the various discovery capabilities as suggested by Watson. It also allows healthcare professionals to type their own inquiry (in the form of questions) once a dataset is uploaded. The lower section shows capabilities of testing relationships or running some predictive analysis.

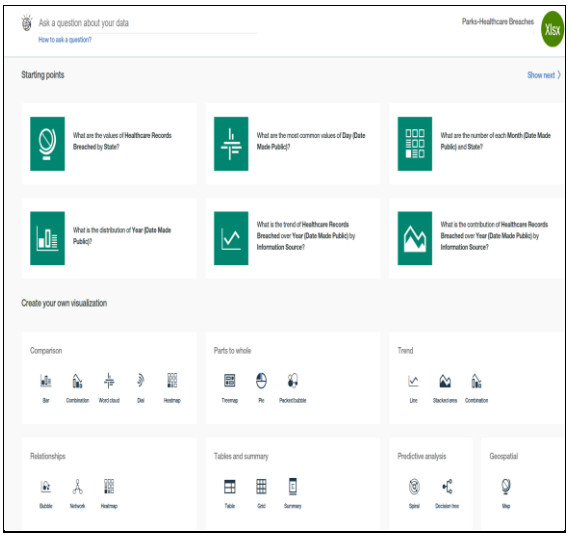

Figure 1. Watson Analytics Discovery Screen

Contextual Active Learning Assignments

We used a variety of assignments, discussion themes, and a term project that align with the course learning objectives. We present three sample course assignments that covered multiple concepts. For each assignment, we present the learning objectives, description and how it aligns with our contextual active learning approach.

Sample Course Assignment: Analyze Medical Data Breaches
- Learning Objectives:
  - Perform Extract-Transform-Load (ETL) of healthcare data dealing with breaches
  - Apply IBM Watson Analytics to analyze healthcare data
  - Perform descriptive analytics to answer the "What" questions
- Assignment Description:

The Privacy Rights Clearinghouse (PRC) Chronology of Data Breaches, accessible via http://www.privacyrights.org/data-breach, is a

nonprofit corporation in California that was established in 1992. PRC keeps up-to-date information of data breaches across all industries and the government within the US. PRC aims to provide timely and historical information on data breaches. PRC reported more than ten billion records breached from over 4500 medical data breaches impacting more than 255 million patients since 2005. Students are asked to apply analytical skills that will produce measurable insights from historical performance data that can be transformed into actionable insights. Students will engage in two major analytic activities: (1) extract, transform and load (ETL) the data; (2) create visualization graphs using business analytics tools (e.g., IBM Watson Analytics). In this assignment, students will focus on descriptive analysis and will be answering the "What" questions in order to provide a view of both current and historical results. Descriptive analytics tells the business how it is performing and help identify key issues in their current performances.

- Contextual Active Learning Focus

The students were required to extract publicly available dataset through PRC website. They purposely selected medical/healthcare data for analysis since healthcare is the context of this course. With a focus on data breaches from healthcare, they found that theses breaches account for almost half of the total reported breaches across all industries. Healthcare data breaches account for over 4500 cases of breaches, and impact more than 255 million patients (PRC 2019). The analysis activities using the contextual active learning approach is forcing students to engage in not only creating visualization charts but also thinking about the extent of the findings and engaging in what they are doing. The engagement and feedback were happening through the required weekly discussions.

Sample Course Discussion: Discuss Healthcare Analytics Issues

- Learning Objective:
  - Identify current healthcare analytics issues for analysis
  - Discuss implication and illustrate with current events/publications
- Assignment Description:

The adoption of big data in healthcare increases security and patient privacy concerns. Write one short paragraph describing concerns/challenges (e.g., privacy, security, ethical, legal, data governance, silos) as a result of big data adoption in healthcare.

- Contextual Active Learning Focus

After watching an entertaining video of ordering pizza (Dedots 2006), students quickly identified some implications and challenges of data analytics. The video portrays the dismay of a customer who was placing a pizza order. Not only information about his phone, national ID, work, and recent travel booking was available to the clerk, but also his health data (high cholesterol and high blood pressure) that caused a premium cost to his pizza, Tying a simple pizza order to health complications puts in perspective the power and possible concerns of analytics. To encourage engagement and discussions about the issues and the context of analytics in healthcare, students were required critique their peers.

Sample Course Project: Working With a Healthcare Industry Partner

- Learning Objectives:
  - Identify a healthcare topic of interest and matching dataset for analysis
  - Analyze healthcare data using healthcare analytics techniques
  - Discuss and communicate findings in writing
- Assignment Description:

The data analytics team, from a teaching hospital, provided a real dataset set to enhance not only the students' learning but also engagement with industry. In this project, students will engage in major analytics activities including but not limited to descriptive and predictive analytics using business analytics tools.

In this course, students are responsible for developing a preliminary research article targeting some of the major questions provided by the hospital analytics team. Students will analyze the data using Watson Analytics software. The final manuscript should introduce the research question(s) in the introduction section, include a literature review, a description of the methodology and findings, and finally a discussion and a conclusion.

- Contextual Active Learning Focus

The author contacted several hospitals in order to provide a true and applied contextual experience in a healthcare setting. It is not a trivial task to get organizations to share their datasets but we have been successful. This is documented by a student who stated "I am excited about the IBM Watson component of the curriculum and even more excited to be working

with actual health care data from our hospital partner. I know how sensitive healthcare data is and how hard it is to find outside of a healthcare organization, so to be working with real data is a big advantage."

4. DISCUSSION

In this section, we discuss the lessons learned and offer recommendations to enhance future deployments. We also discuss students' assessment of this course.

Lessons Learned

We present some of the key challenges we encountered throughout this course in the form of lessons learned:

Textbook or No Textbook

While designing and developing this course, we were able to put together the topics to cover based on the author's industry experiences, research in healthcare analytics and assistance from other experts in industry and education. Once the topics were identified, we selected a textbook. The first challenge we debated for months whether to assign or not assign a textbook for this interdisciplinary course. We erred on the side of assigning a book simply because the course is delivered online, and it provides a sense of structure to the students. Selecting the appropriate book for any course is not trivial. However, when the course is interdisciplinary and assumes different background for students, the task becomes very daunting. We attended vendors' booths at Information Systems and Health Informatics conferences – Americas' Conference on Information Systems (AMCIS), the Information and Management Systems Society (HIMSS), and the Conference on Information Systems and Computing Education (EDSIG) – and approached professors and editors about health analytics books. This task was a very challenging because 1) there is a limited number of books that covers data analytics in healthcare and 2) among the few we found, each book was taking a completely different perspective. The first book looked promising based on the description. After we ordered and reviewed the book, it was almost anecdotal. The second one was business/managerial in nature, and we almost went that route before realizing it barely discussed healthcare dataset sets or different analytical methodologies. Finally, we chose a book edited by Chandan Reddy who is a Computer Science professor and Charu Agarwal who works at IBM Research Center (Reddy and Aggarwal 2015). Our initial reaction was not to use the book because it may seem geared toward computer science degree students especially with some sections getting into the algorithms behind the different methods. Then, we closely assessed the content of each chapter, and noticed the variety of academic and industry background of the authors writing each chapter and thus providing the interdisciplinary features that met the course learning objectives. For example, Chapter 1 is written by a computer scientist and IBM researcher while chapter 3 is written by employees of the biomedical image analytics lab at GE Global Researcher. Chapter 4 is written by employees at the IBM Watson research lab and College of Medicine researchers while chapter 12 is written by sciences researchers from the School of Information Library Science.

While the book touches on the major learning objective set for this course, we still have some reservations. Some chapters are written by computer scientists where much attention is focused on the algorithms which is outside the scope of the course and our graduate business students. This was alleviated by making clear to students that while the details are great, they are not part of this course and students are not expected to learn nor memorize this material. The other reservation pertains to the book lacking coverage of the social and behavioral aspects of data analytics, such as privacy, patient engagement and ethics topics, but those were easily covered in the course through relevant research articles.

Software Platform

The software used has a significant impact on the overall class. As tempting as it may be to expose the students to different analytics platforms, we learned from other data analytics classes we taught not to introduce many data analytics platforms during one course offering. This is also recommended by other researchers who state that using many applications enriches the students' experiences but also has major drawbacks especially with the width of coverage and the lack of depth needed to perform the analysis (Asamoah et al. 2017). As this is an elective course (with statistics as prerequisites), we did not have to worry about covering the statistical or analytical foundations of business analytics. Therefore, our focus was on a 1) widely used software in industry especially in

healthcare, 2) moderately challenging but not overwhelming software so it does not take away from the contextual learning of healthcare, and 3) finally offering both descriptive and predictive capabilities. We selected IBM Watson Analytics as our platform to meet the above criteria.

Interdisciplinary Backgrounds and Flexibility

We assessed the academic backgrounds and professional experiences of students taking this course (See Appendix C). A total of 21 were enrolled in this elective business analytics course with academic background varying from management information systems to fine arts and actuaries. All students who completed this information (19 students out of 21) are currently working in a variety of industries (healthcare, insurance, government, manufacturing …). Despite the disparities in their academic backgrounds and work experiences, all of the students reported on the use and need of analytics in their current jobs. Such interdisciplinary in backgrounds provided a very rich platform for discussions for each module and allowed students to apply their learning to their work environment and engage beyond the requirements of the course. This also dictated a flexible structure to move from an assigned term project to a project allowing students to use their own dataset.

Contextual Active Learning

The combination of a data analytics and healthcare attracted students to this graduate elective course. Based on utilizing an active learning approach, we introduced several learning objectives for each module and align each activity (e.g., assignments, readings, discussions…) with the learning objectives. With the course being contextualized in healthcare and half of the students working in healthcare or related field (healthcare insurance), the assignments especially the term project and the weekly discussions took a much deeper undertaking both at the data analysis and discussions activities.

Online vs. On Ground

This course was offered online which is different from on ground offerings. The development of the course did not make any assumptions about knowledge or skills. For instance, we set a webinar with the librarian to offer a session on how to search for discussion articles, use different databases and search engines. In an on ground class, the entire activities would have a show of hands to check if they know how to search for scholarly articles. Sensitive to different backgrounds, skills are necessary to create a conducive learning environment.

Healthcare Domain

Despite the first module being dedicated to analytics in the context of healthcare, students worked on interpreting data/models without a clear competency on the sector of healthcare itself. The absence of a clear and dedicated overview of general healthcare domain knowledge could be easily alleviated by providing such background to all students in the first module.

Learning Assessment

The course evaluations have shown that students gave positive feedbacks of overall satisfaction with the course. We assessed students' perceptions of the course impact and instructor effectiveness through a survey using a 5-point Likert scale (see appendix B). The results of the survey are provided in comparison to other courses within the College of Business. The students (n=10) rated the instructor the overall teaching ability at 4.6 out of 5.00 in comparison to the average of the school of business instructors rating at 4.0 out 5.00. They acknowledged that the instructor brings current ideas and emphasizes the intersection of healthcare and analytics and summarizes which is crucial in contextual settings as stated by one student in the survey:

> *"Very helpful, intriguing, enlightening, and extremely relevant to the real world."*

In alignment with an active learning approach, the course included a variety of individual and group activities that were not only engaging but yielding maximum learning in technical, analytical and team work skills. For instance, one student stated:

> *"I felt group activities were engaging and required group members to utilize relevant technical and social skills to collaborate."*

Another student commented:

> *"I think this class has a healthy balance of individual work assignments and team assignments. During my early days in the Business Analytics program, many of the courses were too heavily centered on group work and there was no individual accountability. The classes are evolving and creating an environment that facilitates maximum learning."*

Though not captured directly by the survey, the open-ended questions provided more feedback on the selected analytics platform. The course aims to create a balance between content and technology on one hand and between students from different background. Students who were already working in industry and from technical background felt a certain level of frustration when they could not manipulate certain functionalities within the selected software.

In addition to the course evaluation completed by students, we are currently considering additional assessment to evaluate the course and modules. New evaluations will include different methods, such as qualitative data gathering from industry stakeholders, and assessment of instructional design and delivery. Incorporating feedback from students, employers and educational designers may further ensure the interdisciplinary goals of this course while ensuring effectiveness of learning.

5. CONCLUSION

This research highlights the need to integrate context-specific learning of analytics through specialized analytics courses. We utilized a contextual approach to creating curricular modules for use in healthcare analytics. The results should contribute to addressing the needs for active-learning and contextualized learning in healthcare data analytics. Thus, developing skilled data analytics experts for healthcare, and providing empirical results on a healthcare analytics course implementation.

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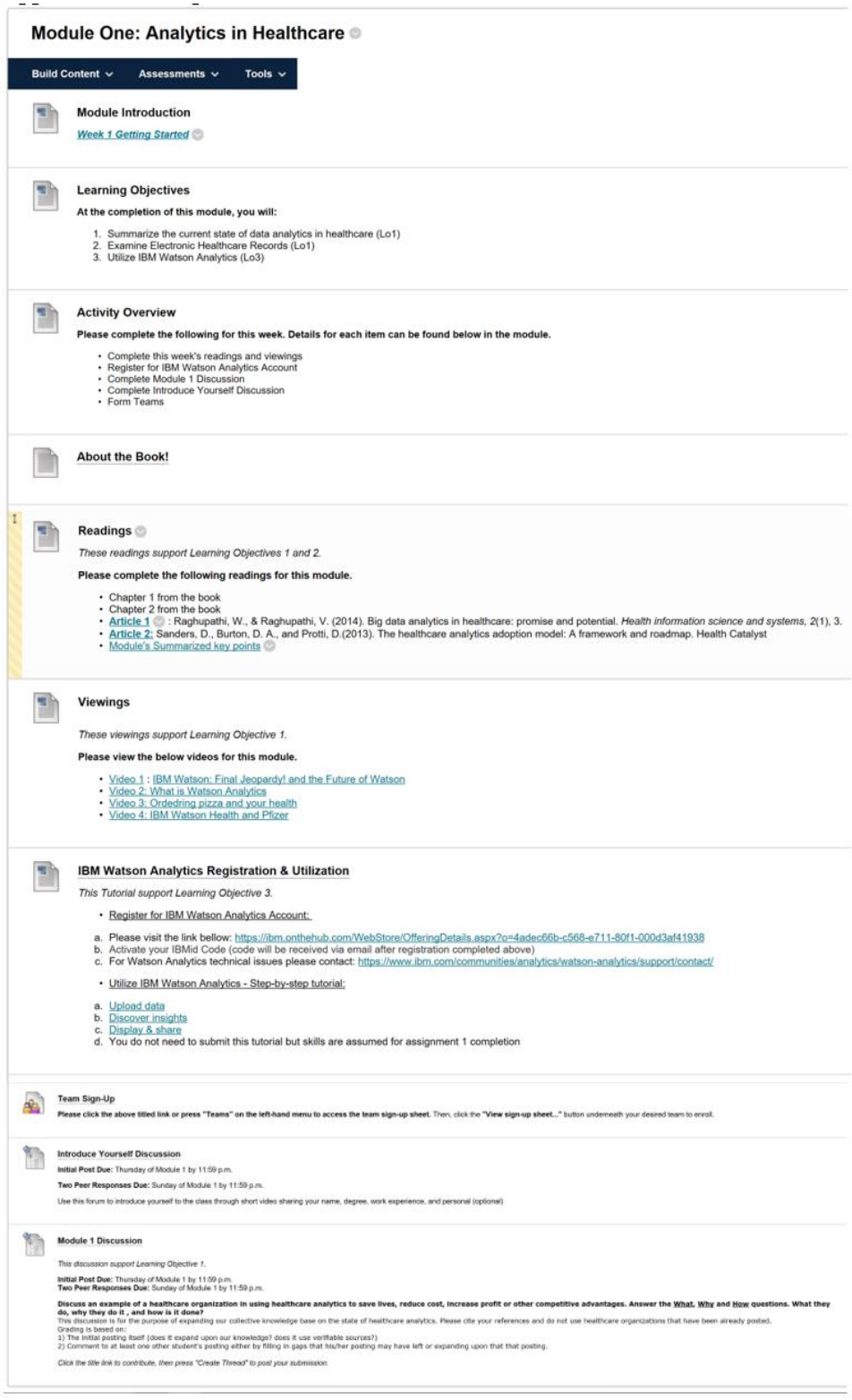
Appendix A – Sample Curricular Module



Module One: Analytics in Healthcare

Build Content | Assessments | Tools

Module Introduction

Week 1 Getting Started

Learning Objectives

At the completion of this module, you will:

1. Summarize the current state of data analytics in healthcare (Lo1)
2. Examine Electronic Healthcare Records (Lo1)
3. Utilize IBM Watson Analytics (Lo3)

Activity Overview

Please complete the following for this week. Details for each item can be found below in the module.

- Complete this week's readings and viewings
- Register for IBM Watson Analytics Account
- Complete Module 1 Discussion
- Complete Introduce Yourself Discussion
- Form Teams

About the Book!

Readings

These readings support Learning Objectives 1 and 2.

Please complete the following readings for this module.

- Chapter 1 from the book
- Chapter 2 from the book
- **Article 1** : Raghupathi, W., & Raghupathi, V. (2014). Big data analytics in healthcare: promise and potential. *Health information science and systems*, *2*(1), 3.
- **Article 2:** Sanders, D., Burton, D. A., and Protti, D.(2013). The healthcare analytics adoption model: A framework and roadmap. Health Catalyst
- Module's Summarized key points

Viewings

These viewings support Learning Objective 1.

Please view the below videos for this module.

- Video 1 : IBM Watson: Final Jeopardy! and the Future of Watson
- Video 2: What is Watson Analytics
- Video 3: Ordedring pizza and your health
- Video 4: IBM Watson Health and Pfizer

IBM Watson Analytics Registration & Utilization

This Tutorial support Learning Objective 3.

- Register for IBM Watson Analytics Account:

a. Please visit the link bellow: https://ibm.onthehub.com/WebStore/OfferingDetails.aspx?o=4adec66b-c568-e711-80f1-000d3af41938
b. Activate your IBMid Code (code will be received via email after registration completed above)
c. For Watson Analytics technical issues please contact: https://www.ibm.com/communities/analytics/watson-analytics/support/contact/

- Utilize IBM Watson Analytics - Step-by-step tutorial:

a. Upload data
b. Discover insights
c. Display & share
d. You do not need to submit this tutorial but skills are assumed for assignment 1 completion

Team Sign-Up

Please click the above titled link or press "Teams" on the left-hand menu to access the team sign-up sheet. Then, click the **"View sign-up sheet..."** button underneath your desired team to enroll.

Introduce Yourself Discussion

Initial Post Due: Thursday of Module 1 by 11:59 p.m.

Two Peer Responses Due: Sunday of Module 1 by 11:59 p.m.

Use this forum to introduce yourself to the class through short video sharing your name, degree, work experience, and personal (optional)

Module 1 Discussion

This discussion support Learning Objective 1.

Initial Post Due: Thursday of Module 1 by 11:59 p.m.
Two Peer Responses Due: Sunday of Module 1 by 11:59 p.m.

Discuss an example of a healthcare organization in using healthcare analytics to save lives, reduce cost, increase profit or other competitive advantages. Answer the What, Why and How questions. What they do, why they do it , and how is it done?
This discussion is for the purpose of expanding our collective knowledge base on the state of healthcare analytics. Please cite your references and do not use healthcare organizations that have been already posted.
Grading is based on:
1) The initial posting itself (does it expand upon our knowledge? does it use verifiable sources?)
2) Comment to at least one other student's posting either by filling in gaps that his/her posting may have left or expanding upon that that posting.

Click the title link to contribute, then press "Create Thread" to post your submission.

Appendix B - Course Evaluation

Name of the course: (Name of the survey) BAN664DE_17FA Healthcare Analytics

Comparative line: Fall 2017 School of Business

Values used in the profile line: Mean

1. *Student Input*

1.3)	Rate the instructor's teaching ability in this class.	Excellent	Poor	n=10 n=4219	av.=4.6 av.=4.0	md=5.0 md=4.0	dev.=0.5 dev.=1.2

2. *Course Evaluation*

2.1)	I have become more competent in this area due to this course.	Strongly Agree	Strongly Disagree	n=10 n=4208	av.=4.3 av.=4.3	md=4.0 md=4.0	dev.=0.7 dev.=0.9
2.2)	I have increased my overall knowledge of the subject matter.	Strongly Agree	Strongly Disagree	n=10 n=4198	av.=4.4 av.=4.3	md=4.0 md=5.0	dev.=0.5 dev.=0.9
2.3)	I feel challenged intellectually by this course.	Strongly Agree	Strongly Disagree	n=10 n=4184	av.=3.8 av.=4.1	md=4.0 md=4.0	dev.=0.9 dev.=1.0
2.4)	The instructor presents the material too rapidly.	Strongly Disagree	Strongly Agree	n=10 n=4190	av.=3.4 av.=3.3	md=4.0 md=4.0	dev.=1.3 dev.=1.3
2.5)	The instructor gives assignments that are too difficult.	Strongly Disagree	Strongly Agree	n=10 n=4177	av.=3.7 av.=3.4	md=4.0 md=4.0	dev.=1.1 dev.=1.2
2.6)	The instructor is available to provide extra help.	Strongly Agree	Strongly Disagree	n=10 n=4185	av.=4.7 av.=4.2	md=5.0 md=4.0	dev.=0.5 dev.=0.9
2.7)	The instructor provides clear answers to student questions.	Strongly Agree	Strongly Disagree	n=10 n=4188	av.=4.6 av.=4.1	md=5.0 md=4.0	dev.=0.5 dev.=1.1
2.8)	The instructor encourages class discussion.	Strongly Agree	Strongly Disagree	n=10 n=4197	av.=4.7 av.=4.3	md=5.0 md=5.0	dev.=0.5 dev.=0.9
2.9)	The instructor brings current ideas to the classroom.	Strongly Agree	Strongly Disagree	n=10 n=4190	av.=4.6 av.=4.3	md=5.0 md=5.0	dev.=0.5 dev.=0.9
2.10)	The instructor has the course well organized.	Strongly Agree	Strongly Disagree	n=10 n=4192	av.=4.7 av.=4.2	md=5.0 md=5.0	dev.=0.5 dev.=1.0
2.11)	The instructor summarizes main points and provides emphasis on material,	Strongly Agree	Strongly Disagree	n=10 n=4187	av.=4.9 av.=4.3	md=5.0 md=5.0	dev.=0.3 dev.=1.0
2.12)	The instructor relates course concepts in a systematic manner.	Strongly Agree	Strongly Disagree	n=10 n=4198	av.=4.8 av.=4.3	md=5.0 md=4.0	dev.=0.4 dev.=0.9
2.13)	The instructor seems to enjoy teaching.	Strongly Agree	Strongly Disagree	n=10 n=4196	av.=4.9 av.=4.4	md=5.0 md=5.0	dev.=0.3 dev.=0.8
2.14)	The instructor is friendly and considerate to students.	Strongly Agree	Strongly Disagree	n=10 n=4197	av.=4.8 av.=4.4	md=5.0 md=5.0	dev.=0.4 dev.=0.9
2.15)	The instructor is enthusiastic about the course material.	Strongly Agree	Strongly Disagree	n=10 n=4186	av.=4.9 av.=4.4	md=5.0 md=5.0	dev.=0.3 dev.=0.8
2.16)	I would recommend taking another course with this instructor to a friend.	Strongly Agree	Strongly Disagree	n=10 n=4183	av.=4.8 av.=4.2	md=5.0 md=5.0	dev.=0.4 dev.=1.2

Appendix C - Students' Academic Backgrounds of Students Enrolled in Healthcare Analytics Course

Student	Seeking MS degree in	Undergraduate Degree Major/Minor	Experience	Industry
1	Business Analytics	Management/ Finance	Advanced development program	Aerospace Manufacturing
2	Business Analytics	Journalism	Account Manager	Technology
3	Business Analytics	Economics/Finance	Informatics	Insurance
4	Business Analytics	History	IT Security Manager	Insurance
5	Business Analytics	MIS	Senior Consulting Analyst	Insurance
6	Business Analytics	Finance/Accounting	Business Intelligence Analyst	Insurance
7	Business Analytics	Accounting and Finance	Analyst	Insurance
8	Business Analytics	Information Science/Mathematics	Healthcare Business Data Manager	Healthcare
9	Business Analytics	Mathematics	Director of Credit Risk Management	Financial
10	Business Analytics	Management	Business Intelligence Analyst	Life Insurance
11	Business Analytics	MIS	Database Administrator/Analyst	Government
12	Business Analytics	Not provided	IT Analyst	Healthcare
13	Business Analytics	Digital Communication	Cyber-Space operation Officer	Government
14	Business Analytics	Actuarial science	Analyst	Insurance
15	Business Analytics	Not provided	Not provided	Not provided
16	Business Analytics	Fine Arts	Data Analyst	Manufacturing
17	Business Analytics	Philosophy/Psychology	Reporting Analytics	Healthcare
18	Business Analytics	Accounting	Financial Analyst	Healthcare
19	Business Analytics	Asian Studies	Director of Operation Risk	Financial
20	Business Analytics	MIS	IT Assistant	Electrical
21	Business Analytics	Not provided	Not provided	Not provided

Digital Badges and E-Portfolios in Cybersecurity Education

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Abstract

The aim of this report is to highlight efforts to develop a digital badging and e-portfolio environment that will illuminate and validate curricular, co-curricular, and extracurricular learning in cybersecurity. This effort includes Cal Poly Pomona and Coastline College, which are both designated as Centers of Academic Excellence in Cyber Defense (CAE-CD) along with a collection of academic and industry partners in creating learning pathways that move interested beginners all the way through to an exciting career in the field of cybersecurity. The pathways are designed to incorporate curricular, co-curricular, and extracurricular learning in a student-managed process in which students consume the learning modules they desire/need, and which move them toward the learning goals they have selected. Students will be able to visualize how formal curricular programs align with their learning journey and plan curricular, co-curricular, and extracurricular learning tasks that fit their plan and allow them to achieve their academic and career goals.

Keywords: Digital badge, skill attainment, e-portfolio, assessment, cybersecurity, education, academic pathways

1. INTRODUCTION

Malcolm Gladwell's prescription of 10,000 hours of practice being required to attain proficiency is an appropriate benchmark for cybersecurity (Manson & Pike, 2014). Reviews of skills required by employers for cybersecurity positions support the notion of students needing extensive training to secure meaningful employment in the field. The mismatch between the skills cybersecurity students can reasonably attain within the classroom and those required by employers demonstrates a need for students to become independent learners and develop additional skills outside of the classroom. Furthermore, Generation Z students are argued to have learning needs and interests that are not, and cannot be, met within current college campuses (Seemiller & Grace, 2017). Generation Z students are also argued to be skeptical of the cost of higher education but are entrepreneurial, innovative, and independent learners (Seemiller & Grace, 2016). The need for extensive skills training and the current inclination of the newest generation of students to be self-directed and entrepreneurial in their learning creates an ideal environment for digital badges and e-portfolios.

Cal Poly Pomona

California State Polytechnic University, Pomona (Cal Poly Pomona) is proud of its longstanding "learn by doing" education philosophy, which provides a competitive advantage for graduates because it extends well beyond students completing hands-on exercises in classrooms. A recently retired professor in Computer Information Systems (CIS) promoted a 50/50 equation meaning that students should ensure that at least 50% of their learning occurs outside of their degree requirements in order to prepare for cybersecurity careers. The CIS program at Cal Poly Pomona promotes competitions, research, internships, and student club activities as venues for students to obtain the "other" 50% of their hands-on learning and skills development. This "other" 50% focuses on competency-based education with students designing, planning, and operating the programs and activities that comprise the learning with support from faculty and university resources.

In the past four years, Cal Poly Pomona has developed the Mitchell C. Hill Student Data Center (SDC) that operates as a hybrid-cloud facility along with a Security Operations Center (SOC) that students operate to monitor the SDC along with studying and researching in the area of cybersecurity operations (Hwang, Pike, & Manson, 2016). There is a companion Malware Analysis Lab (MAL) operated by Computer Science students that focuses on research and learning in the area of computer malware. These facilities are brought together with others under the Cyber Security Instructional Research Project (CSIRP) at Cal Poly Pomona as an extension to the academic programs on campus. The SDC provides computing capabilities for learning modules in courses, competitions, research projects, and more. The SDC also provides cybersecurity learning environments for local middle and high school students.

Initially, students worked as many as 10 hours per week and would invest several hundred hours of work in the SDC and SOC during their time in the program. However, as the program has grown, some students are working as many as 20 hours per week and starting in their 2nd year in the program, thereby amassing thousands of hours of work in the SDC and/or SOC during their time in the program. All of this time devoted to the operations of the SDC and SOC are filled with meaningful learning experiences yet few, if any, are captured in a student's academic transcript.

During the four years the SDC and SOC have been operating, the technical skills required of students within the SDC have continued to rise. After just the first year of the program, students who wanted to start in the SDC or SOC were unable to gain success in activities at either of the facilities as they lacked the needed skills. The SWIFT (Students With an Interest in the Future of Technology) student club came forward to host workshops on topics from Linux, to computer networking, and more, in an effort to prepare students for participation in the SDC and SOC. SWIFT developed an organizational unit called SWIFT Academy that focuses on providing such training.

Student staff from the SDC and SOC then teach additional advanced workshops that build upon the introductory workshops taught by students from SWIFT or other campus clubs. An ecosystem has emerged in which students are teaching workshops that have learning objectives, syllabi, and pedagogies that are subject to a faculty approval process. Students are also running a production hybrid-cloud data center and security operations center. Through these efforts and recognition of the need for practical learning outside the classroom, there is now a defined set of prerequisites between the workshop courses and workshop completion

requirements before Cal Poly Pomona students can start working in the SDC or SOC.

Student-led workshops have already begun to crossover into course curriculum and vice versa. In some cases, faculty will recommend students in their class attend a particular workshop and even offer course assignment credit or extra credit for workshop participation. In other cases, faculty will adopt the content from a workshop and insert it into his or her course as a project or curriculum module. Likewise, student clubs will sometimes take popular technical modules from courses or even corporate training (with permission) and create workshops from that material for students that will not be taking the particular course, or students who need to learn the technical skill before they have taken the course that contains the content.

The process of teaching workshops, operating competitions, and participating in research projects along with the SDC and SOC engages more than 100 students per term in extra-curricular activities to develop hands-on technical skills outside the classroom. Many of these students dedicate hundreds or thousands of hours of time learning and practicing the skills required, which in nearly all cases, are not reflected in any official academic transcripts. More than 1,000 students attended these workshops and programs during the 2018-2019 academic year. Digital badges were determined to be the only tool capable of creating a companion instrument to a student's transcript to document students' skills and activities demonstrated within the curricular, co-curricular, and extracurricular programs at Cal Poly Pomona. E-portfolios were determined to be the appropriate instrument to display pathways created through badges leading students to their desired academic goals as well as being the tool that will allow students to represent their learning journey along with the evidence to demonstrate their skills.

Coastline College

As a 2-year public degree awarding and transfer institution, Coastline College (Coastline) recognizes the value of developing academic pathways for students coming in from the high school and those planning to go on to the 4-year colleges and universities after completing a 2-year degree at Coastline. To draw in students from the local middle schools and high schools, Coastline has developed structured pathways to engage these students with events and activities that include Cybersecurity Pathway Days, CyberTech Girls events, GenCyber summer camps, and cyber defense competitions such as CyberPatriot and Capture-the-Flag. These events are held at Coastline's Garden Grove campus in Southern California to build the relationship between the students, the college, and its faculty members. The activities include training and hands-on workshops that raise awareness about Coastline's cybersecurity program and help students develop their skills and interest in cybersecurity professions.

Hosting these types of events, allows Coastline to expand beyond the traditional outreach strategies hosted at the middle school and high school campuses in which students may talk to faculty at a career fair table without much time for hands-on activities. By hosting the cybersecurity activities at the college campus, Coastline showcases the classroom equipment, learning environment, and hosts learning and awareness activities to help students from the 8th-12th grades to become familiar with and prepared for the college setting.

Coastline is exploring the use of digital badges within its Learning Management System to track student progress and achievements for GenCyber and CyberTech Girls events. Students will be able to earn badges after completing practical exercises and assessments that demonstrate a particular level of skill attainment. In the coming year, Coastline will begin exploring the use of Portfolium to track student program progress and successful industry certification exam attempts to guide students in further development of a robust e-portfolio.

Additionally, Coastline offers dual and concurrent enrollment courses at high school campuses in the Orange County, CA area. The concurrent enrollment courses offered in the Santa Ana Unified School District (SAUSD) are taught by Coastline College faculty and SAUSD students are bussed from multiple high schools to one high school campus for weekly class meetings. This allows the students to earn college credit while in high school and begin developing cybersecurity skills in preparation for cybersecurity roles or for their extracurricular activities at Coastline or Cal Poly Pomona's SDC and/or SOC.

Coastline's dual enrollment with La Quinta High School (LQHS) includes college-credit courses taught during the regular school day, by an LQHS teacher. In addition to the college coursework, many of the students compete in

the CyberPatriot competition hosted at Coastline. The Coastline courses offered at LQHS include Network+, Security+, and Ethical Hacking which will provide students with cybersecurity skills that they can continue to develop as they move to higher education institutions.
Coastline has established agreements with 4-year institutions through the Learning 1st Program, allowing Coastline students to concurrently enroll in both the 2-year degree courses and 4-year degree courses at Coastline and a University. This is sometimes referred to as a 2+2 program in which students receive full transfer credit from the 2-year school to the 4-year school's bachelor's degree program. Students complete 2+2 programs to earn both the associate and bachelor's degree by taking classes at both schools in a major with pre-determined courses.

2. LITERATURE REVIEW

There is a growing body of literature around digital badges revealing optimism regarding the potential impact on skill attainment and advancement. Terms including digital badges, micro-credentials, or even credentials denote web-enabled depictions of an individual's accomplishments or skills (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2015). A first key area of common ground within the literature focuses on the ability of digital badges to reveal learning pathways, making these pathways transparent to learners (Pitt, Bell, Strickman, & Davis, 2019; (Davis & Singh, 2015; Gibson et al., 2015; Pitt et al., 2019). These learning pathways can be a mix of formal curriculum in an academic program along with co-curricular or extracurricular learning activities.

Conversely, the pathways can be completely comprised of extracurricular activities including industry-based learning and badging/certification options. A second key area of common ground within the literature focuses on the ability of digital badges to validate possession of a key skill (Gibson et al., 2015; May, 2016). Examples of skills validation for employees is evident in the literature and trade outlets from industries spanning human resources to AV installation, and education to construction (Berry, Airhart, & Byrd, 2016; "First micro-credential A big step forward for construction," 2018, "Introducing micro-credentials for AV installation," 2017, "NPA introduces parking safety certificate program: Micro-credential program provides parking facility safety and risk reduction tools," 2016; Goerner, 2016; Gorlin, 2018).

Literature varies on the appropriate scope of a digital badge. There is strong support in the literature for a badge reflecting an individual skill or accomplishment (Goerner, 2016; May, 2016). Others; however, add to this by comparing badges today to e-commerce in the latter 1990s with the notion that education providers who ignore badges could begin a steady decline (Hickey, 2017).

E-portfolios have an immense literature base that reflects many uses for this technology. E-portfolios are used in classrooms to assess student learning and in program-level assessment (Wang & Jeffrey, 2017). E-portfolios are also used as digital resumes for students to display evidence of learning to potential employers or higher-level education admissions, or to demonstrate professional development in an individual's workplace.

The review of literature focused on education, nursing, and law. Education was a point of focus as Cal Poly Pomona is deploying e-portfolios in an education setting. Medicine and law were reviewed as they are professional disciplines and have been argued to be appropriate reference disciplines for information systems (Davenport & Markus, 1999). Within medicine, we focused on nursing literature as it has a strong focus on application that matches well with the cybersecurity field.

The first major benefit found for e-portfolios is centered around learners' self-reflection and self-regulated learning (Carl & Strydom, 2017; Chin-Yuan Lai & Cheng-Chih Wu, 2016; Rafeldt et al., 2014). A second major benefit of e-portfolios was found in helping learners to tell a media-rich story related to their learning journey (Haverkamp & Vogt, 2015). Yet another benefit of e-portfolios found in literature is the ability to link theory to practice (Chittum, 2018; Cunningham, Bartesaghi, Bowman, & Bender, 2017). There are many more benefits of e-portfolios that cannot be fit into this paper, however this paper simply reported on the dominant benefits found pertaining to the goal of this paper. Also, there is a large literature base supporting the three benefits of e-portfolios presented here which have been limited to just the few that best supports the purpose of this paper.

3. DIGITAL BADGES & E-PORTFOLIOS

The research study examined digital badges and e-portfolios to enhance and assess co-curricular and extracurricular student activities that support the information systems program at Cal Poly Pomona. The ability to accurately assess co-curricular and extracurricular work is especially important in a polytechnic setting as there is a significant focus on resources and the importance of experiential, hands-on learning activities. This research sought to determine the efficacy of these technologies with respect to serving as a tool to report student-learning outcomes in activities that span formal curriculum as well as co-curricular and extracurricular learning activities. Digital badges are becoming increasingly important as they are a specific measure of skill attainment that can be tied to in-demand technical workplace skills.

Digital badges can also provide evidence of skill achievement in co-curricular and extra-curricular programs between schools. For instance, a student may earn badges in high school that allow them to start in more advanced opportunities at the community college. Badges earned in high school and community college may allow students to start work right away in the SDC or SOC at Cal Poly Pomona without spending the year that is typically required to gain the skills to start working in these facilities. This is especially important for transfer students to ensure they get started immediately in these facilities as they only have two years to complete their bachelor's degrees.

Digital Badges

A digital badge is a shareable credential providing evidence of a learning achievement. Digital badges fall into two categories which are competency and participation badges. A competency badge requires an assessment of skills and measures of achievement. The badge description includes the items that were assessed and the performance outcome that was required to earn the badge. Participation badges indicate that an individual has participated in an event, such as attendance at a workshop or lecture. The competency and participation badges are sometimes offered in tandem where an individual has attended a workshop and then successfully completes skills test at the end to demonstrate learning.

The literature supports three distinct drivers supporting the use of digital badges. The first driver is the potential motivation for students in earning a badge as an extrinsic reward for excellence or even drive engagement by linking students' achievements within a leaderboard and creating a competitive element to learning (Denny, 2013; Gibson et al., 2015). Second is the potential for a digital badging system to help students envision integrated curricular, co-curricular and extracurricular learning paths that prepare them to enter careers (Pitt et al., 2019). The third driver is the potential for digital badges to help students demonstrate the collection of skill attainment to better market their skills, knowledge, and relevant experiences to potential employers. There is support for the notion that companies are seeking ways to gain additional insight into the skills and abilities of applicants and digital badges are a potential solution (Raish & Rimland, 2016). There is also evidence that CIOs are seeking to gain insight into the skills of current employees meaning that digital badges may already be a valued asset within IT organizations before a student applies for employment (May, 2016).

Figure 1 shows a brief example of an overly simplified learning pathway for demonstration purposes. In this case, a student took an advanced placement (AP) Python course while in high school, a Computer Networking course from a community college, and a Linux course from Lynda.com. This group of badges/certifications allowed the student to qualify for the SOC Associate badge at Cal Poly Pomona which is a collection of sub-badges. The student would then be able to immediately begin working in the SOC Associate role in the Security Operations Center at Cal Poly Pomona and begin working on the Splunk certification, which is earned directly from Splunk, and the SOC Operations badge which comes from successfully completing a battery of tasks and 100 hours of work as an analyst in the SOC. A student can progress through this learning pathway without any formal articulation agreements as the SOC (along with the SDC) are extracurricular environments. Of course, proper planning should ensure that the AP Python course taken in high school and the Computer Networking class from the community college each articulated to appropriate courses in the Cal Poly Pomona curriculum. The student would not likely receive academic credit for either the Linux course or Splunk certification, but this would be known in advance allowing the student to plan accordingly.

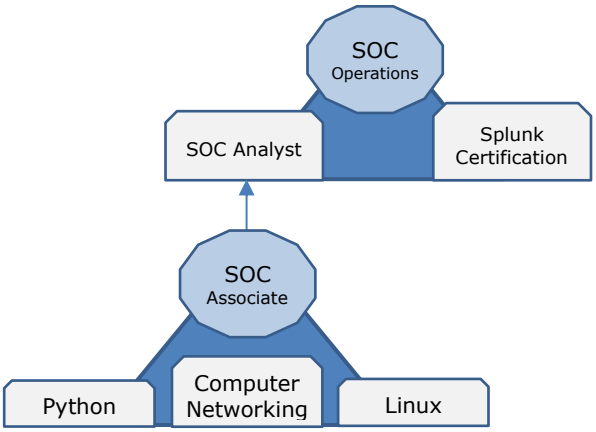

Figure 1 SOC Learning Pathway

More than a dozen employers of cybersecurity students from Cal Poly Pomona have asked for the implementation of digital badging systems. Employers such as IBM and AWS have entered into a joint badging process in which students earn some badges from Cal Poly Pomona and some from these companies while they are in school. Cisco has recently announced a scaling back of their certification programs, to be replaced by the implementation of digital badging. This process of digital badging appears to be growing and it is believed that it will become pervasive over time.

E-Portfolios

As noted in the literature review, there are three distinct drivers for the use of e-portfolios which were learner self-reflection, learner storytelling, and linking theory to practice (Carl & Strydom, 2017; Chin-Yuan Lai & Cheng-Chih Wu, 2016; Chittum, 2018; Cunningham et al., 2017; Haverkamp & Vogt, 2015; Rafeldt et al., 2014). Portfolium has been selected and procured for use in Cal Poly Pomona's e-portfolio and digital badging venture.

E-Portfolios and Digital Badging

At Cal Poly Pomona digital badging and e-portfolios are implemented in Portfolium, a commercial product. Portfolium is a complete solution, providing completely integrated digital badging and e-portfolios. Badges can also be output to professional networking platforms such as LinkedIn and other digital platforms from Portfolium. The benefits derived from e-portfolios and digital badging for Cal Poly's program are shown in Table 1. The integration of e-portfolios and digital badging, and then the subsequent integration of these two technologies to existing systems such as Cal Poly Pomona's Student Information System (SIS) have been reviewed; however, are expected to create a challenge throughout the e-portfolio/badging implementation process.

Table 1 *E-Portfolio and Digital Badging Benefits*

Benefits of E-Portfolio and Digital Badging	
E-Portfolios	Digital Badges
Self-reflection	Extrinsic Motivation
Storytelling	Illuminate learning pathways
Linking theory to practice	Market to employers or higher-level education

Several literature sources speak to e-portfolios supporting learning and evidence of achievement (Trevitt, Macduff, & Steed, 2014). However, in Cal Poly Pomona's environment digital badging are viewed as being the tool that offers evidence of achievement and the e-portfolio as a system to support evidence of learning. Likewise, Cal Poly Pomona is planning to use e-portfolios to support evidence of learning in a mixed environment of curricular, co-curricular, and extracurricular work but this will overlap to at least some extent with the function of the SIS. The process of determining which information is maintained, managed, and assessed in which systems will certainly create lively debate among stakeholders on campus.

4. CHALLENGES OF DIGITAL BADGING AND E-PORTFOLIO USE

There are several badge e-portfolio platforms currently on the market. A quick online search shows over thirty such solutions. However, the premise is on adoption by the e-portfolio systems and professional social media platforms such as LinkedIn as to acceptance. Many platforms and applications can accept badges in their rudimentary state as a bitmap or other digital graphic file. This demonstrates that there is an ambiguity of acceptance currently emerging in this area.

Enter open badge standards. The Mozilla Foundation has developed a technical standard called Open Badges and since the early 2010's they have endeavored to develop a contextual framework for organizations to adopt their standard through a partnership alliance (LaFrate, 2017). This concept has solid

foundations through the professional and academic measurements of rigor for the eventual holder of a certification, certificate, or degree. The general stance in academic and professional development is that digital badges are an evolutionary step for learners to gauge their progress (Stotz, 2017).

A question then comes to the accreditation and broad acceptance of badges within and across organizational lines. In much the same way that one university accepts another's courses for articulation purposes, the focus on digital badges opens up another realm of possibility. This can contribute to the badge accreditation process in the form of compact skill assessments that map up to joined learning objectives that two or more institutions share. The other side of the argument and more challenging aspects are the technical and platform-specific hurdles that can get in the way of accomplishing these agreements.
A possible solution to this would be a generally accepted standard throughout higher education. However, as previously stated, with over thirty badging solutions and limited e-portfolio guidance there is a challenge present in this space for collaboration. Only time and further research on adoption of platforms will show the direction of digital badges and e-portfolios in higher education. as with many types of technological advancements, until either a breakthrough or in this case a more "viral" moment occurs, we as educators will experiment with different methods, platforms, and products all the while sharing our research in the quest to advance this pedagogical and andrological initiatives.

5. OPPORTUNITIES FOR FUTURE RESEARCH

While previous research and the findings of the study provide a promising framework for pathways with supplemental credentialing through digital badging and micro-certificates housed in an e-portfolio repository, there are areas that need additional attention and research to move the framework forward. There is a need to understand the process for establishing, articulating, and updating industry and higher education standards for badging and e-portfolios. Following this idea, is a need to measure the rate or speed of digital badging and e-portfolio adoption by industry and higher education. Finally, once badging and e-portfolio standards are established and fully implemented there needs to be a measure of the impact of digital badging and e-portfolios on rates of graduation, transfer, job attainment, job promotion, and employee retention.

6. CONCLUSION

E-portfolios and digital badging are an exciting option to demonstrate skill achievement outside the classroom, extend cybersecurity learning, and provide or illuminate pathways for learners. Cal Poly Pomona and Coastline College are both designated as Centers of Academic Excellence in Cyber Defense (CAE-CD) and are working with academic and industry partners to make technical skills pathways transparent to learners from middle school all the way into professional careers. This project focuses on empowering learners to understand the challenges and opportunities ahead of them through digital badging and e-portfolios that can be used to show the pathway early on and track achievements along the way, culminating in a more complete display of the learners skills and achievements inside and outside the classroom. It also provides a perspective for the development, implementation, and refinement of a learning journey that includes a broad array of content and potential patterns to consume the content. Cal Poly Pomona and Coastline envision learners ultimately assembling an academic transcript and an e-portfolio with digital badges that summarize the learner's career preparation. This learning journey would then continue as the learner manages career advancement and market shifts in the workplace. Finally, the challenges are explored facing the accreditation and acceptance of digital badges and e-portfolios in academia and industry alike. Further research needs to be conducted to develop badges into established pathways that are widely recognized and accepted.

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Creating Business Analytics Dashboard Designs using Visualization Methodologies: Case Methods for Innovative Analytics Pedagogy

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Abstract

Teaching business analytics has become a critical requirement in many business schools to stay competitive, and the search for real-world examples of business analytics applications is a subject of great interest among analytics instructors. Instructors want to be able to show students how to develop and build business analytics applications that can effectively help real world business decisions. In this research, we aim to develop teaching methodologies to design visual analytics applications that are effective at the classroom and at the same time practical for students to relate to when building their own dashboard application. This research attempts to showcase these designs in case studies where analytics applications are create to help students understand how they are used in various business operations.

Keywords: Business Analytics, Application Design, Dashboard Design, Design Methodologies

1. INTRODUCTION

The sheer amount of data and analysis needed in today's business environment needs to be addressed by visual interfaces that are intuitive to use and easy to comprehend (Keim, Kohlhammer, Ellis, & Mansmann, 2010). The overwhelming amount of textual and numeric data is difficult to decipher without the help of visual analytics. Dashboard design is an important tool in creating effective analytics applications. According to Jerath, Crawford, & Barnes (2015), over fifty percent of the human brain is dedicated to vision and visual representation.

The purpose of this paper is to share various dashboard design methodologies used in a business analytics class, which has been effectively used by students to create their own customized dashboard projects.

In order to understand the details of creating an effective visual representation such as a dashboard application, we need to understand how the human mind perceives visual information. Essentially, human perception responds to – color, shape, motion, and depth of objects seen by the human eyes (Mueller, 2010).

Accentuating certain visual patterns can quickly alert human perception of certain information and effectively help human cognition in digesting data more effectively and in turn, help people make more informed decisions. Thomas (2007) stated that visual analytics can provide solutions and opportunities to resolve information overload. Colors and unique shapes of objects can alert human perception to critical and dynamic visual information, especially when the information is represented in unique object shapes and color codes. Motion like animated charts and real-time adjusting numeric representations also improves human perception of data. Depth, represents three-dimensional representation, which may be better than just flat two-dimensional representation. Visual

design layout of dashboards are also critical for improving perception, since layout can give clarity to navigate through information clutter.

2. LITERATURE REVIEW AND DESIGN METHODOLOGIES

Looking at the dashboard design literature, there are several recommendations for designing a good dashboard application. Hertz (2019) summarizes the best dashboard design practices in a few words "Make the complex simple; tell a story; the data visualization needs to correctly reflect the data; and reveal details as needed (no more no less)." Durcevic (2019) has several design recommendations including "choosing your end goals before putting the design elements in place; choose your layout and colors; prioritize simplicity; and use interactive elements" to name a few. Smith (2012) talks about using multiple data representations, such as using secondary statistics in a dashboard display to support a metric and give it better context. For example, instead of just stating that sales has increased by 25,000, a dashboard can also show that it grew by 25% from last month. The 25% percentage growth is the "secondary statistics" that give the raw sales data a better context. Smith also recommends displaying small charts alongside numeric data to improve visualization.

In this research, we look at several techniques to improve the design of business analytics applications. The following are some methodologies we used:

1) Redundant Visual Representations - When viewing a dashboard application, a digital representation may not be enough. We may also need an analog representation at the same time to enhance visual data perception. Watchmakers have used this dual analog-digital presentation when designing watches, where you have a numeric digital representation of time and also have the three hands of an analog clock showing the hour, minute, and seconds of the time in the layout of the watch. Woodford (2019) explains that both analog and digital displays have their own merits in conveying information that appeals to various users. When designing visual applications and depicting data output as a gauge, it helps when you have dials to show where the numeric value is in an analog form in addition to showing a numeric value. (See **Figure 1** in Appendix).

2) Clear Layout for Input and Output Objects – In any information systems, there are generally three major processes – (1) inputting data into the system, (2) processing that data into useful information, and (3) and generating an output to show meaningful knowledge that can be extracted from that data. Determining what inputs are important will ultimately show how effective the output is in helping the user of that system. In a dashboard application, there are visual objects that you can use as your data input. These data input objects are used to adjust any data input for purposes of data manipulation and data simulation. On the other hand, there are also visual objects that you can use as your visual data output or data results. For example, in a car, a 'gauge' is a visual data output. A speedometer gauge shows the results of your speed as you step on the gas pedal. The speedometer gauge is the visual data output that helps you monitor how fast you are driving, while the gas pedal is your input mechanism. However, in this example, the gas pedal is not a visual input but a mechanical input. In a dashboard application, you can use visual dials or sliders to adjust your data input (See **Figure 2**).

3) Using Colors for Indicators – the human eye can easily spot certain color indicators more easily and there are ways to make certain data patterns stand out. According to Dashburst (2018), "Color has been known to have a powerful psychological impact on people's behavior and decisions. And this knowledge has been harnessed all too well in marketing psychology by designers and marketers alike. Color can often be the sole reason someone purchases a product. In a survey, 93 percent of buyers said they focus on visual appearance, and close to 85 percent claim color is a primary reason when they make a purchase." Color coding is part of the visual strategy for using colors effectively.

4) Story Telling and Creating Visual synergy – Creating an Analytics application needs some story telling. What do you want to convey to your audience. How does your application interest the user and how will the data tell the story. An application will need the right elements to attract audience to use them. For example, if you are developing a predictive analytics application to forecast a future scenario, the user will assess whether you have taken into consideration the most important data that can affect the accuracy of future scenarios. The user will also assess whether the mathematical and statistical model is logically and theoretically sound.

5) Defining the Scope of your Application and Range of Data – Analytics applications are meant to be compact and effective. A dashboard designer cannot put too many variables into it or it will be too cumbersome or complex to use, unless it is customized to for one specific user or a very few specialized users. The idea of analytics dashboard is to keep it as simple and as user-friendly as possible, and not to encumber data analysts with extra variables that have minimal impact on the outcome. So, the Dashboard application will have its own limitations in terms of scope. The data variables may also have a limited range, because in the real world you try to measure or benchmark certain data in a certain range of values. For example, when designing the speedometer of a car, the range is normally from 0 – 180 or 200 miles per hour. It does not make sense to create a range to include 1,000 miles per hour, because no car on the road will exceed that kind of speed.

3. CASE 1: MORTGAGE ANALYTICS

The first case aims to teach students how to create a mortgage analytics application. All banks and mortgage lending institutions use some form of mortgage analysis to help their clients decide on questions like (1) how much they should borrow on a housing mortgage, (2) can they afford such a mortgage, (3) if they have an existing mortgage, will they save money if they refinance their existing mortgage?

There are several factors that determine the monthly amortization or payment of a mortgage. And these are (1) the loan amount being borrowed, (2) the term of the loan (whether it is a 30 year, a 15 year, or a 10 year mortgage, (3) the interest rate of the mortgage (shorter term mortgages tend to have lower interest rates), and (4) the escrow amount, which is an amount the bank collects on a monthly basis to pay for the yearly realty tax on the property and the home owners insurance. So, to create a mortgage application, it is safe to assume that these four factors (loan amount, term of the loan, interest rate, and escrow amount) are the basic adjustable data inputs that determine the outcome or output. The output is to find out what the monthly amortization or payment is. The data output report can be two-fold, one showing the monthly amortization without the escrow payment and the other showing the monthly amortization payment with the escrow amount being paid. The reason that it is important to show two outputs is that the monthly amortization for a fixed 30 year mortgage payment will not change for 30 years, but due to the rising cost of home insurance and potential changes in real estate taxes, the escrow amount could change from year to year.

If the bank's client has an existing mortgage, we can add one additional data input and that is the current mortgage amount the client is paying. We can also add one additional data output and that is, how much will the client save if the client refinances to a new mortgage. It is a logical expectation that many home owners who are interested in refinancing their mortgage wants to lower their monthly mortgage payments, and possibly save a few hundred dollars in monthly mortgage payments.

In **Figure 3**, we built an analytics dashboard application for mortgage analysis using SAP Business Objects Dashboard. We decided to create a layout where most of the data "input variables" are on the left side and the "output variables" are on the right side of the application template. On the left side, the input variables include the Loan Amount, Interest Rate, and Escrow Amount. On the right side, the output variables include Monthly Amortization with No Escrow and Monthly Amortization with Escrow. SAP Business Objects can import Excel formulaic functions like the =PMT formula that calculates mortgage payments based on loan amount, interest rate, and the term of a loan.

In the middle, a dropdown menu was created allow users to choose a loan term of 30, 20, 15, 10 and 5 years. If a client has an existing mortgage and wants to refinance that mortgage, that data can be inputted there, and an output

data shows the savings realized from the refinancing effort is also indicated. In Figure 3, we can see a client has an existing mortgage payment of $1,350 and that client is getting a new mortgage payment of $993.57. The difference between the two amount results in a savings of $359.43 per month.

In **Figure 3**, the application also uses a redundant method of using both 'horizontal progress bars' and 'dials' allowing users to use any of the two data input objects to adjust the loan amount, the interest rate, the escrow amount, as they please. Using redundant representations makes it easy for users to use adjustable visual input objects as they see fit.

4. CASE 2: SALES ANALYTICS (USING AN INTERACTIVE DATA MAP)

For the second teaching case, we use a fictitious small company selling 6 different products across 50 states. The input object is an interactive map (see **Figure 4**). If the user hovers the mouse pointer above the location of a particular state on the map, it will pop up the total sales number of that particular State on the map. And it will create a real-time output of the sales breakdown in a pie-chart and a table for each product in each of the 50 U.S. States. A second pie-chart also shows the percentage of sales that a particular state contributes in relation to the total sales of the company. The data on the map is linked to the pie charts and the tables. When a State is choose in the map, the pie chart and table data automatically shifts to that particular state's data.

The map is color coded to depict different sales levels. The green colored states reflect sales that are below $10,000. The purple colored states are those that have sales between $10,000 - $15,000. The yellow colored states are those that have sales between $15,000- $20,000. And the Red colored states are those with sales above $20,000. The application allows users to determine what color to use.

5. CASE 3: PREDICTIVE RETIREMENT ANALYTICS

For those who are planning for retirement, it is always difficult to determine if their nest egg or life savings can last thirty or forty years. There are several critical factors that affect the longevity of one's retirement savings. Most individuals contemplating retirement can benefit even from a simple predictive analytics model that can help them estimate how long their retirement funds can last. In a very simple predictive analytics model (see **Figure 5**), there are at least five input data variables that can determine how long one's retirement nest egg can last. (1) The starting balance of one's nest egg upon retirement, (2) the age of the retiree, (3) the average yearly growth of one's investment portfolio base on the historic performance of the stock market in the last few decades (measured by the Down Jones Industrial Average and the S&P 500), (4) how much one withdraws from their retirement savings every year as their retirement income (based on their yearly budget for yearly living expenses), and (5) the projected inflation rate, which erodes the value of money year over year. So the yearly withdrawals from savings will increase base on the yearly inflation. If a person can live or survive on a budget of $48,000 per year at the start of their retirement and they have social security income at $12,000 per year, then they will need to withdraw $36,000 from their retirement savings to supplement their social security income. On the second year of their retirement, they will need to adjust the $36,000 spending budget due to inflation. If inflation is 2%, that means they will need to withdraw $720 more on the following year ($36,000 x 2% = $720). This assumes that social security is also inflation adjusted.

The retirement analytics application allows users to adjust the input variables located on the left hand side of the application, and it should determine if the retiree still has some savings left at the end of a 30 year or 40 year retirement period. The right side of the application shows gauges that determine the savings left after 30 years and 40 years of retirement.

6. CASE 4: INDIVIDUAL CUSTOMIZATION OF RETIREMENT ANALYTICS

In Case 3, we developed a dashboard analytics application that can be quickly used by anyone to create a more generic predictive analytics for retirement. However, we created another predictive retirement dashboard application for Case 4 (see **Figure 6**) that is individually customized for a person who had plan to retire at 53 years old and was about to reach that age in a few months. Since the person was only 53 years old, he had 6.5 more years to be able to withdraw from his 401K and IRA account at 59.5 years old without incurring a 10% tax penalty, so he has to rely on his cash savings and determine if his cash savings will be depleted soon. The person also planned to withdraw

social security income with his spouse at the age of 62 years old, so we customized a dashboard application just to see the balance of his cash at 62 years old, and the potential income he could receive at 62 years old as he and his spouse plans to take their social security at that age.

The person also took into consideration that there is an Internal Revenue Service (IRS) loophole called Substantial Equal Periodic Payment (SEPP) that would allow him to withdraw from his retirement account before reaching the age of 59.5 years old without the 10% tax penalty. SEPP (Appleby, 2019) allows people to withdraw an equal amount of funds for 5 years or more, but the withdrawal must be an "equal amount". It means that if a person decides to start withdrawing $12,000 a year from their 401K, then they must withdraw $12,000 a year for the next 5 years and they cannot change that amount to follow the SEPP IRS rules. So, this is an option if an early retiree feels that they will run out of cash before they reach 59.5 years old or 62 years old when social security is available. This individual also plans to do part-time work in different age periods of retirement, but plans to earn less as he approaches the age of 62-63 years old. So, we included four adjustable income gauges for different age periods in the dashboard application. At 62 years old, the person also plans to put most cash into Municipal Bonds earning 6%. So the customized dashboard has a multiple income source tally at age 62, from his social security income, his wife's social security income, his 401K withdrawal at 4% per year, and municipal bond income at 6% (**Figure 6**).

7. SUMMARY

In these four dashboard application design cases, we used the design methodologies we discussed earlier in the paper. We used redundant visual representations to display both analog and digital representations for the data we want to convey to the user effectively. In the mortgage analytics applications, for example, we used a gauge with analog dials and a digital display of numeric values. In the design methodologies, we discussed how colors and color coding is important in dashboard design. We used color coding to represent different data representations like the interactive map with colors representing different numeric sales value. We also used color codes for data inputs, like horizontal bars, and output objects, like gauges. For the retirement analytics, a negative balance results in the gauge range as red, and green if it is a positive number.

In terms of the layout for the mortgage analytics and the retirement analytics, we placed the input variables on the left side of the template, and the output variables on the right side of the template. The interactive sales map, which acts as an input object, for the user to choose a specific state is also on the left side of the template, and the right side of the template shows the breakdown of the sales data based on the state chosen on the map.
For the individually customized dashboard analytics for retirement, most of the inputs are on the left side and the output gauges are on the middle and the output chart is on the right side.

As indicated in the design methodology, each of these application tell a story about how various input variables are related and affect the output variables when the input data is adjusted by the user. The input data variables can be adjusted on the fly and create various output scenarios in real time based on how the user of the application configures the input data variables. Once the users visually adjust the input variables, they immediately see the real-time adjustments on the output variables.

In all the dashboard applications, we followed the design methodology to stay within the scope of the application envisioned in terms of including all the inputs and outputs we wanted to present, telling the right story, designing an intuitive layout and using colors appropriately to improve cognition. We also designed a realistic range of data, like setting a more realistic range for inflation rates and interest rates.

In the classes where we taught these design cases, students were required to create the mathematical model in Excel first where they see how input variables affect output variables. Then, we imported the mathematical model in Excel to the SAP Dashboard application and then designed the Dashboard objects (like gauges, data bars, charts) around the Excel mathematical model. The SAP Business Objects allow you to link these Dashboard objects to specific Excel-like cells. Students are asked to design about 5 to 6 of these dashboard cases. After they have a feel of how to model and represent data in a dashboard application, they are then required to collect data they want to analyze and design their own dashboard projects. They are graded based on (1) purpose of their dashboard application, (2) the data they collect, (3) the mathematical model they create, and (4) the layout, colors, and design details of the dashboard, and (5) the overall synergy of

their dashboard application and its parts and how it appeals to the user.

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Appendices and Figures

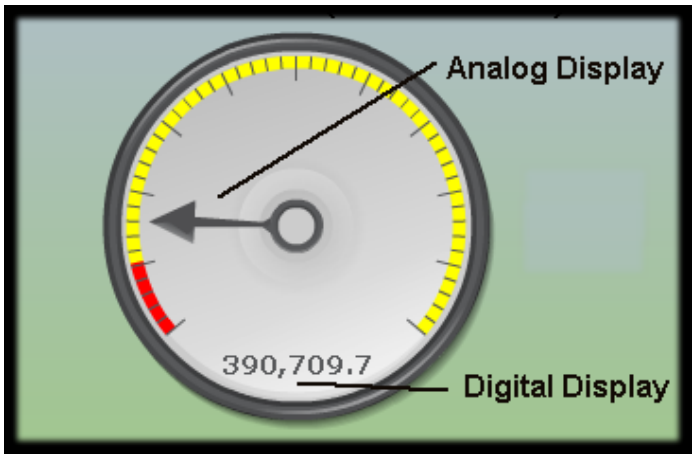


Figure 1. Redundant Representations - Analog Display (dial on scale) and Digital Display (numeric)

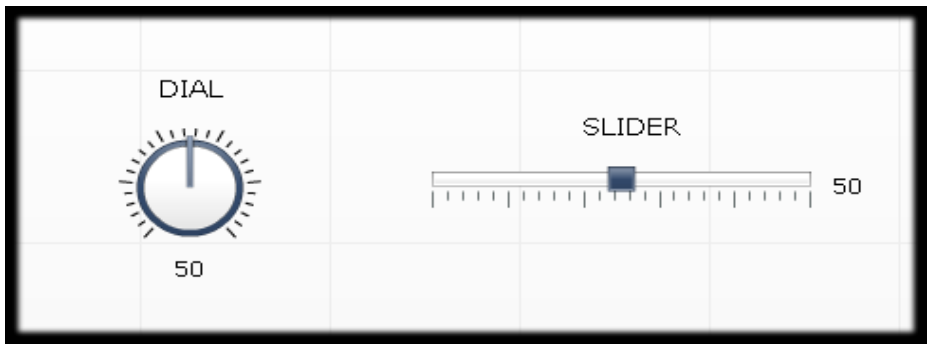


Figure 2. Dials and Sliders as objects used to visually adjust data Input with a mouse pointer

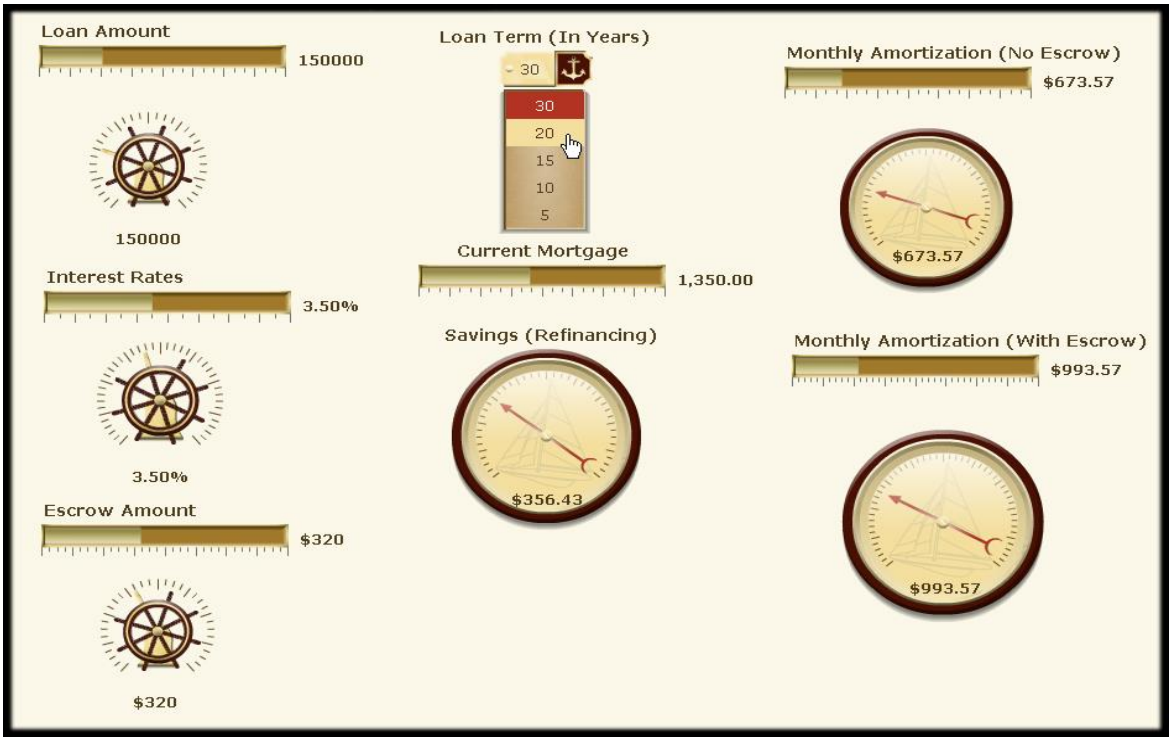
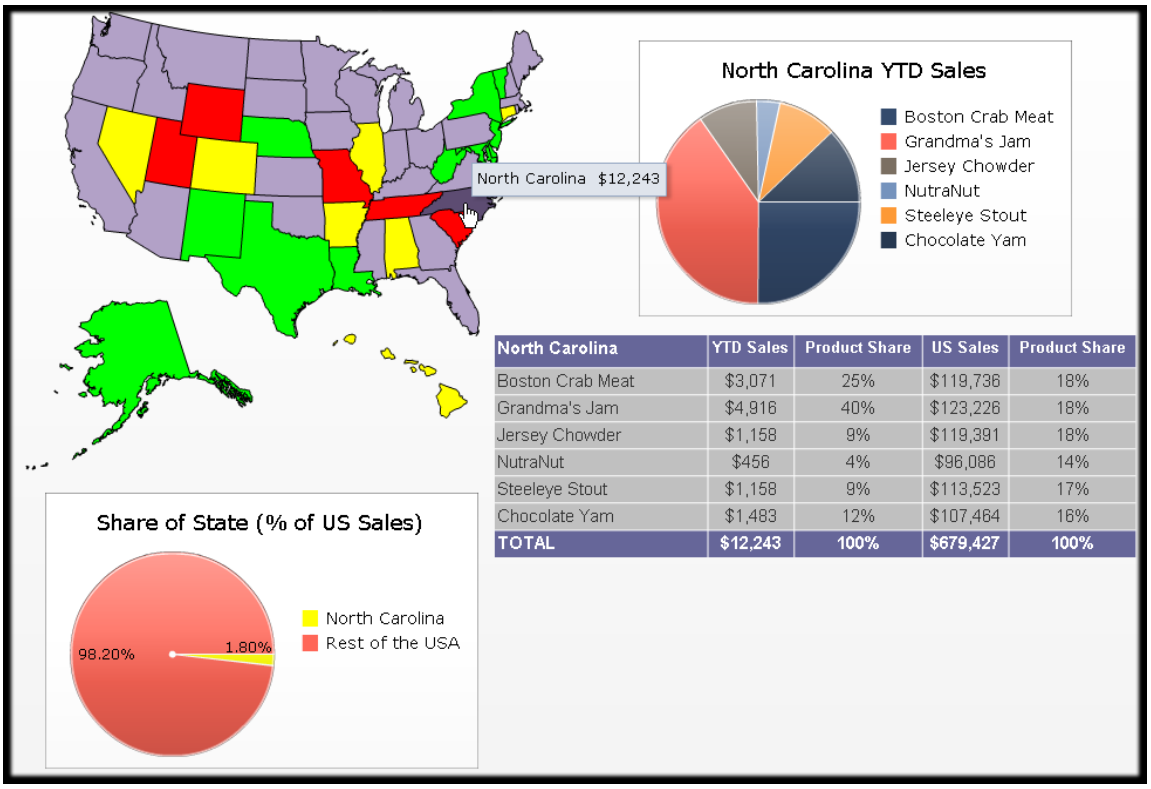


Figure 3. Mortgage analytics with most input objects on the left side and output objects on the right side



North Carolina	YTD Sales	Product Share	US Sales	Product Share
Boston Crab Meat	$3,071	25%	$119,736	18%
Grandma's Jam	$4,916	40%	$123,226	18%
Jersey Chowder	$1,158	9%	$119,391	18%
NutraNut	$456	4%	$96,086	14%
Steeleye Stout	$1,158	9%	$113,523	17%
Chocolate Yam	$1,483	12%	$107,464	16%
TOTAL	$12,243	100%	$679,427	100%

Figure 4. Interactive Map of the Sales numbers for each state.

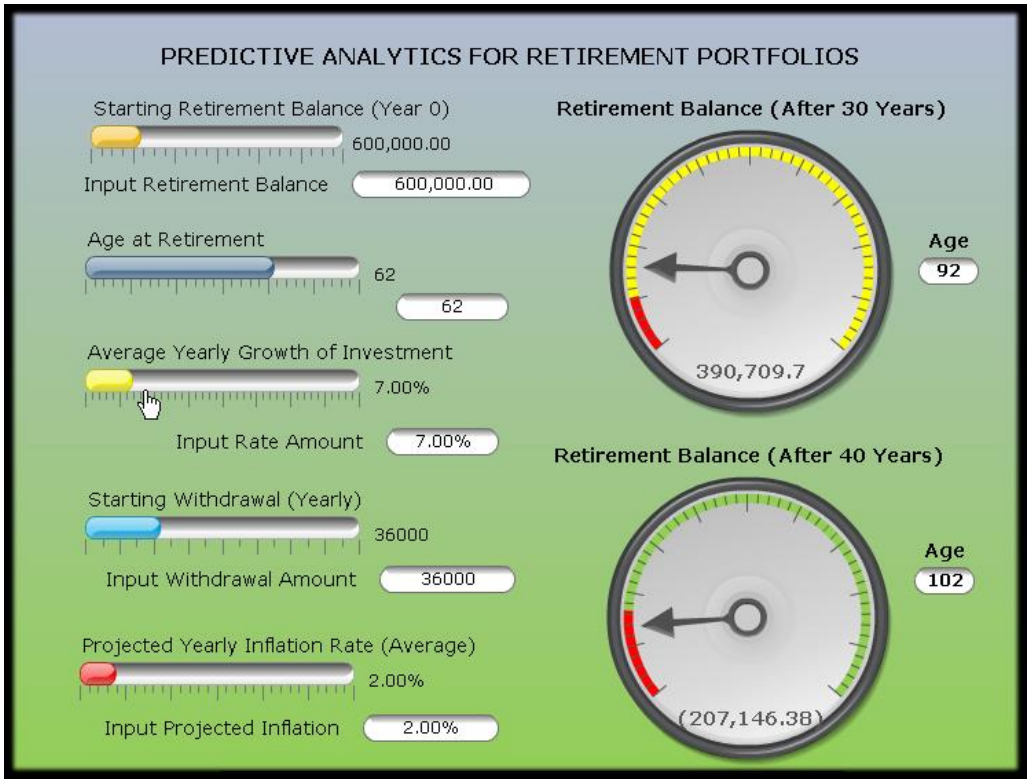


Figure 5. Creating a forecast for retirement

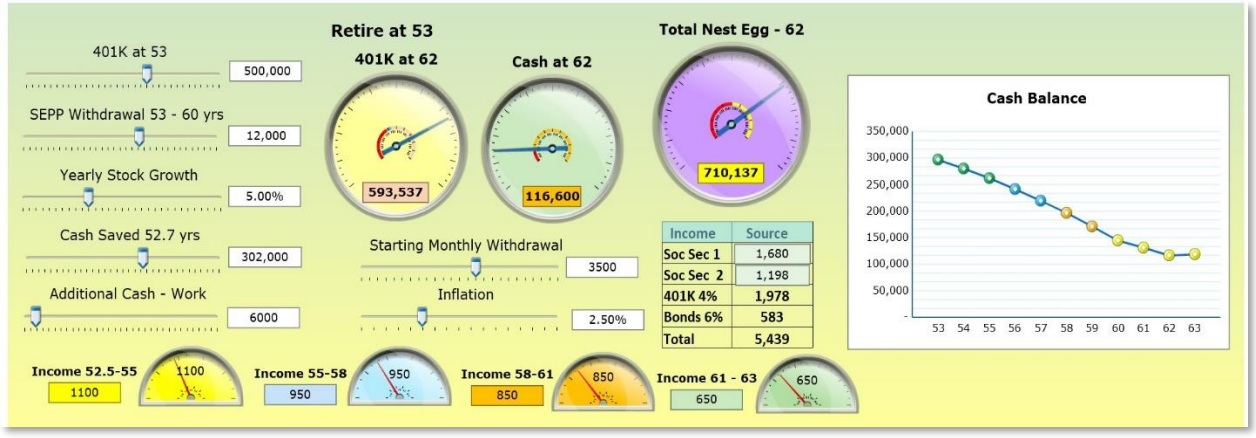


Figure 6. Customization for Individual Retirement Analytics

*All figures are originally created by the author(s)

Using Folklore, Fables, and Storytelling as a Pedagogical Tool in Assessment Exams

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Abstract

Fable-based learning, folklore-based learning, and narrative pedagogy are terms used to represent the use of storytelling for learning complex topics. These learning tools build on narrative theory via our understanding of the role of metaphor and metaphorical reasoning in the learning process. Narrative theory postulates that humans are natural storytellers and interpret the world through narrative. Academic examples of narrative-based learning abound in mathematics, science, business, psychology, and computer information systems. Outcomes of this teaching tool may include overcoming resistance to learning, increased learning, enjoyment, openness to new beliefs and perspectives, and increased learner engagement. We observe that the application of narrative-based learning is currently limited to teaching and lecturing. We propose extending narrative-based learning to the assessment phase of pedagogy. The assessment phase is a knowledge-verification process where learning is measured through exams or assignments. We explore how storytelling can be used in the design of assessment exams and give two examples of multiple-choice exams that uses narrative-based learning principles in a Management of Information Systems course and a Production and Operations Management course. Students were accepting of the exam format and found the exam enjoyable. A subset of students preferred this type of exam to traditional exams. Some students report test anxiety decreased. We propose that storytelling in assessment exams have the potential to reduce test anxiety, increase enjoyment, increase cognitive fluidity, and increase perceived realism or relevance of the learning objectives. We invite other researchers to explore this domain.

Keywords: assessment exam, folklore-based learning, management information systems, narrative theory, metaphoric reasoning

1. INTRODUCTION

In the Chinese folkloric tale of the *Romance of the Three Kingdoms*, three heroes attempt to overcome the oppressive ruling government by recruiting Chinese soldiers from local villages. The three heroes disagree regarding how many soldiers to recruit from each village, as each village has solders of differing strengths, costs, and availability. A celestial, wise man gives the three heroes a magical tablet to help solve the problem given the constraints. Through the use of storytelling and metaphoric devices, such as the aforementioned folklore, the story introduces the learner to a case where discrete mathematics can be understood as a solution to what is a resource maximization problem. This method of teaching is called folklore- or fable-based learning. This particular Chinese folklore is used in a three-course series of MOOCs by Dr.

Stuckey and Dr. Ho Man Lee regarding modeling for discrete optimization (https://www.coursera.org/learn/basic-modeling). They also used the Chinese folklore as motivation in the homework assignments. We found the disarming nature of folklore a compelling and worthy educational tool worthy of investigation.

A fable is a fictitious short story with a moral or learning objective and may involve heroes, animals, or legends. The Grasshopper and the Ant is a classic Aesop's fable that teaches the value of steady, hard work to prepare for lean times. Folklores are traditional beliefs and stories of a community or culture. Legends are traditional stories regarded as historical but unauthenticated. These are subgenres of narratives (see Figure 1). Given a near-universal appeal, it is little wonder that storytelling has been adapted to the academic environment.

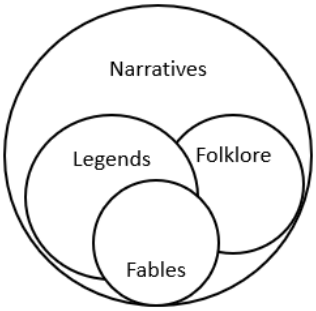

Figure 1. Types of narratives used in pedagogy

Storytelling has been utilized as a pedagogical tool in business, management, math, and information systems (IS). Austin, Nolan, and O'Donnell (2016) use storytelling in The Adventures of an IT Leader. The protagonist, CIO Jim Barton, faces problems running the company's IT department, such as managing technology needs, security, relationships with vendors, and employees. The storytelling format makes the book enjoyable to read, particularly for non-IS business students who may be uninformed about or fearful of technology yet required to take an IS course in a college of business.

Dr. Eliyahu Goldratt (2016) wrote a fictitious novel called The Goal: A process of Ongoing Improvement that has been used in some Operations Management courses. The storyline is of a manufacturing plant manager who overcomes a series of problems to improve the output of his plant. Through the story, the reader experiences production problems and their associated pains, observes the thought processes of the protagonist, and observes the results of the application of the Theory of Constraints to resolve the given production problems. Whereas the learning objective of the book is to educate the reader regarding the Theory of Constraints, Dr. Goldratt chose a novel instead of a text-book format as, in his opinion, the complexity of the content is more understandable, relatable, and applicable when conveyed in a narrative (2016). As readers, we too found that The Goal was a very enjoyable way to learn principles of operations management from Dr. Goldratt and we have used his book when teaching Operations Management courses.

Pan et al. (2006) use another famous Chinese's folklore called the Monkey King. They use the storyline with a multimedia learning system to motivate students to learn about visualizing fourth dimensional mathematical objectives. They report that the folklore helps increase motivation to learn and helps with the visualization of complex mathematical objects.

Our paper extends prior research in folklore-based learning by asking the research question of how storytelling can be used in the assessment phase of pedagogy.

2. LITERATURE REVIEW

Assessment is a process of determining whether learners have achieved the instructor's desired learning goals. An academic learning process starts with an instructor forming specific learning objectives, determining the mode of delivery and content, fostering a learning environment (e.g., delivering a lecture, reading assignment, case study, hands-on activity, service learning, etc.), and assessing the attainment of learning via assessment tools (e.g., exams, assignments, etc.). Finally, the instructor reflects on the learning and improves the process. Angelo (1999) argues that quality assessments foster continuous improvement and results in a higher-quality learning environment for the student.

Multiple choice exams are arguably the most popular assessment tool in academia (Xu, Kauer, & Tupy, 2016). Yet, these exams have several notable limitations. Students prefer free response exams over multiple choice exams as a more accurate reflection of their abilities (Newble, Baxter, & Elmslie, 1979). According to Brassil and Couch (2019), multiple choice responses provide limited insight into the degree to which students believe the answer options. Further, the rote mode of learning such that a

student can carefully read the answer, and select the correct answer, even without retaining the knowledge, misses the point of assessment by providing a false positive. Multiple choice exams may only assess lower-cognitive recall rather than measure the higher-order thought intrinsic to the nuances of problem solving in homework assignments or essays or projects.

Narrative Theory

Pedagogy is a process designed to foster new beliefs or new knowledge within the student. According to Narrative theory, humans are natural storytellers who understand and interpret experience as ongoing narratives (Fisher, 1984). Narrative theory builds on three principles: transportation, identification, and realism. Transportation explains how a narrative can influence a reader's belief by integrating attention, imagery, and feelings that occur in response to a narrative (Green & Brock, 2000). Narratives can aid that cognitive process. Identification is the action by the reader to adopt the perspective of a character (Busselle & Bilandzic, 2009). Realism is defined as a judgment of authenticity from the reader's point of view. Table 1 summarizes the theoretical view points and findings of prior research regarding folklore-based learning.

Table 1. Research regarding folklore-based learning

Research Conclusions	Authors
Narrative theory states humans are natural storytellers and interpret experience through narrative.	Fisher (1984)
Students preferred folklore-based learning over traditional lecture. Struggling students' performance increased more with folklore-based learning.	Lee, Lee, and Lau (2006)
Students enjoy storytelling in mathematics and teachers find it an effective instructional tool.	Zazkis and Liljedahl (2009)

Zazkis and Liljedahl (2009) categorize storytelling according to goals: to introduce a topic, to explain a concept, to ask questions that make the students reflect and think, or to introduce an activity. Hopfer (2012) expresses five key outcomes from storytelling as a knowledge-transfer tool: 1) ability to overcome resistance in the reader, 2) engage less involved audiences, 3) reach audiences that lack specific knowledge, 4) make complex information understandable, and 5) culturally ground the message to the target audience. We next explore the deeper cognitive processes that underlie transportation, identification, and realism by exploring how human cognition relies on metaphors, and an appreciative system of sense-making, to accept and utilize new knowledge.

The Role of Metaphor in Learning

Humans comprehend the world from two different perspectives: 1) from within the world, and 2) being surrounded by the world. Psychologist McGilchrist characterizes this dichotomy by describing the divided brain, i.e., right and left hemispheres (McGilchrist, 2019) This divided brain provides a context for understanding memory, cognition, re-cognition, abstraction, tacit knowing, learning, and imagination. A metaphor is a representation of or symbolic of something else, particularly something abstract (e.g., allegory, parable, analogy, emblem, etc.). Of interest is McGilchrist's assertion that metaphorical understanding is essential to the internalization of a phenomenon into tacit systems of knowledge. We know something because we experience through metaphorical internalization. Metaphor is the fulcrum that balances and integrates our objective and subjective comprehension of new phenomena to reconcile new phenomena against extant explanatory models of the world around us. Thus, metaphor, to which we ascribe the compelling components of the fictive narrative mechanics upon which fables rely, is a relatively timeless teaching device. It centers on coping strategies to engage that which is unfamiliar (Goldstein, 2005).

McGilchrist suggests that the brain's right hemisphere contextualizes experience with our sensory systems. The left hemisphere serves as a comparison engine that categorizes and encodes experience into abstraction. Memory is constantly classified and categorized against metaphoric pictures available for further recall by means of association in context, sensory assessment, and analogical reasoning. Thus, the brain's right hemisphere operates experientially in the present and the brain's left hemisphere assesses sensory input from the right brain and searches for recognition through a catalog of related metaphors. In this sense, a story is disarming because the process of associating the hard facts of new phenomenon places greater

cognitive load for the metaphor-processing left brain.

From McGilchrist's observations, the brain's right hemisphere filters and frames experience in parallel to recognition and thus allows for extant models to be verified. Narratives can be used to reinforce the lesson over time where the story is metaphorically "attached" to the "hard" lesson. These two sense-making engines, the brain's left and right hemispheres, are cooperative and intraoperative in a constant metaphor-matching process. This is a process of recognition (a repeated reconsideration of new data against old) that forms the basis of recall and the ability to act competently against this recall in new situations. Recognition may be expedited and made more familiar when storytelling is utilizing in earlier stages of comprehension.

Metaphor Fuels Processes of Appreciation
Geoffrey Vickers (1983) characterizes the system of comprehending from the right- and left-brain partnership as one of appreciation. Appreciation is also a reconciliatory process which includes the social dimension of reasoning from new experience and comparing the new experience to extant models to establish veracity. This is a knowledge-building process but one that is also grounded in social shaping. This leaves room for the crafting of fables and folklore as they are often grounded in a culture, a context, and laden with value and ethical assumptions. If a fable is meant to be both disarming and relatable, then the narrative in a story must resonate with the learning for whom the story was designed. The universality of themes in the narrative would assume that the ethical precepts in the fable are resonant across cultures and quasi-universal in nature.

The appreciative system conditions the comprehension of new experiences and is open for potential modification as a result of the encounter with new experience. Metaphorical and allegorical device deployed in storytelling targets the learner's appreciative system. Education is goal-seeking. There are lesson plans designed to produce learning outcomes against goals, but the learner's appreciative system is the medium within which that lesson plan and pedagogy will take root.

Such systems are not honed and shaped independently of the communities in which the learner resides. These communities promulgate and reinforce common knowledge, norms, and routines that are acculturating in nature. The learner possesses a world-view grounded in the communities which have shaped them. Regardless of our description of a technical rationality that might dominate the world of education, business, and the professions, the rationality under which the learner operates at any given time is a complex amalgam that goes beyond binary descriptions such as "technical" or "reflective." Rather, the metaphors operating within fables serve as a tool to resonate within a learner's appreciative system, and the modes of rationality favored therein, to encourage incremental comprehension. Metaphors serve as a learning tool by disarming natural reactions to the unfamiliar when referents in our abstract mental models have difficulty in finding a match to new experience.

Principles of narrative learning
Narrative learning involves many of the same principles in any good storytelling. The key is to align the elements of the story with the teacher's learning objectives. Zazkis and Liljedahl (2009) identify seven principles to consider when creating a story for learning: plot, conflict, imagery, human meaning, sense of wonder, humor, and patterns. These same principles can be followed when writing a story for an exam.
Given the benefits of narrative learning, we propose extending the same principles to the assessment phase of learning. Following a learning phase, the instructor wishes to assess whether learning has occurred. The most common assessment tool used in academics is the multiple choice exam (Xu et al., 2016). We explore the potential benefits of using a narrative learning paradigm to multiple choice exams. We developed a story plot and inserted exam questions throughout the story. The following research questions are investigated.

1. Can storytelling be used to assess knowledge attainment?
2. What would an assessment exam which uses storytelling look like?
3. What are the potential benefits of an assessment exam using storytelling?
4. What constraints might exist with this type of assessment?

3. METHOD AND IMPLEMENTATION

When designing an exam, an instructor can write one long story and insert exam questions throughout the story (Figure 2). Each exam question could be a challenge or conflict that the main character needs to resolve. The advantages of a long storyline may include the

following: 1) the exam taker may feel immersed into a plot, 2) more complex plots can be presented, 3) and the single plot may foster a perception that the student is not taking an exam but interacting with a story.

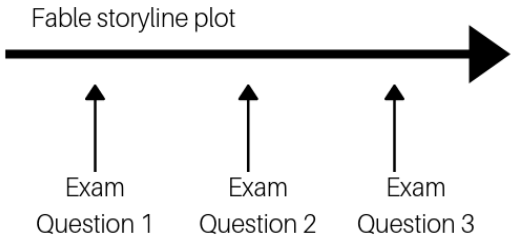

Figure 2. Integrating exam questions into a single, long plot.

An alternative method could be to create a different short story for each question (Figure 3). Each question becomes a very short story, like a mini-business case, not related to the other stories or exam questions. This method is easier to write as the author doesn't need to be consistent between stories. This method also allows the exam questions to be delivered in any question order.

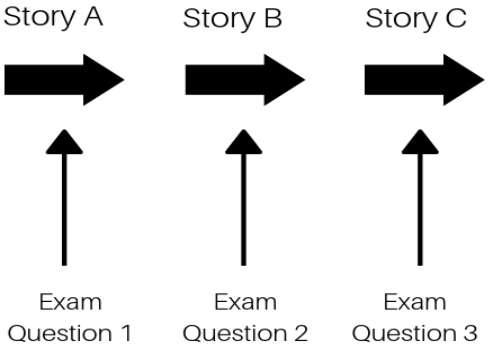

Figure 3. Each exam question could be a mini story not related to the others.

We chose to follow the first method of writing one long story with multiple questions related to the plot because a longer plot is more congruent with the principles of folklore-based learning. We followed a seven-step process for creating the assessment:

1. Define the learning objectives
2. Write questions for each of the learning objectives. Consider Bloom's Taxonomy of Higher Cognitive Thinking to vary the types of questions across the different cognitive levels (Bloom, 1956).
3. Write an introduction that describes the setting and main characters of the story.
4. Add exam questions and possible answer choices to the story.
5. Write prose around the questions to integrate the exam question into the plot. Use the exam questions as problems that the main characters in the story must solve.
6. Review the story against Zazkis and Liljedahl (2009) six principles of teaching through storytelling
7. Edit the story as needed.
8. Deploy the exam through an online learning management system.

Learning objectives

Before the assessment, the teacher should clearly define the specific learning objectives. Specific learning objectives are different than course learning objectives (CLO). CLOs are larger, broad capabilities the students will accomplish after the course is completed. A course may have four to six course learning objectives. An example of a course learning objective could be "...transform web application design instructions into integrated HTML, CSS, and JavaScript code." Specific learning objectives are quantized, fundamental units of knowledge that the learner needs to accomplish which collectively achieve the course learning objectives. Examples could be "...demonstrate the use of class selectors when adding CSS styling to a div or paragraph" or "...create and link an external stylesheet to multiple web pages." A course may have a hundred specific learning objectives which are mapped or aggregate into the course learning objectives. The teacher assesses specific learning objectives through an exam or assignment. One question on an exam could assess one specific learning objective.

For this research study, specific learning objectives were determined by the instructors of a Management Information Systems (MIS) course and a Production and Operations (P&O) course. See Appendix A and B for the exams.

Plots

The story was written in second person so that the reader (student taking the exam) could insert themselves as the main character. For the MIS exam, the student assumes the role of a business executive in a fictitious company. The CEO of the company presents various business problems to several executives. The supporting characters ask questions related to the specific learning objectives of the exam. The student answers the questions. Knowledge of the principles of MIS is required to answer the questions. For the P&O exam, the student is magically transported back in time to meet the

legendary George Washington. The student assist George Washington and his Continental army using knowledge of linear programming and other P&O topics.

Storyline and exam integration

The exam questions need to be integrated into the storyline. One way is to have supporting characters ask questions of the main character. The student answers the questions posed by the supporting characters. An example is as follows.

> You work for a consulting company called IBG, Inc. Your CEO calls you into a meeting with many other executives to discuss problems and solutions to the company's efforts. David starts by saying, "Thank you for coming. I was on the plane yesterday from Asia and read in a magazine article by Tom Friedman on how Toshiba uses UPS to do repairs for Toshiba customers. Toshiba customers make a request for a laptop to be repaired. UPS picks up the laptop and takes it to a UPS warehouse where UPS employees fix the laptop and return it to the Toshiba customer without a Toshiba employee touching the product. This has costs and speed advantages for Toshiba. I think Friedman called this brown sourcing. "
>
> You laugh and quickly stop yourself.
>
> David says to you, "What? Do you have something to say?"
>
> You reply, "I'm sorry. I didn't mean to laugh. Permit me to correct the term. It's not brown sourcing. Friedman called the process _____"
>
> Question 1. What term describes the process David is referring to (according to Tom Friedman's The World Is Flat)?
> A. Offshoring
> B. Insourcing
> C. Informing
> D. Open sourcing
>
> David replies, "Thanks for correcting me. I appreciate it and am not above correcting. Let's move on."

Deployment

The MIS exam was given to 40 undergraduate students in a college of business. The course was delivered online. Deployment was through a learning management system with automatic grading. The Blackboard learning system does not have a mechanism for writing text between exam questions, so the prose related to each question was included in the question text. The questions were ordered in sequence according to the plot. The research purpose of deploying the MIS exam was solely to demonstrate its use and work out any logistical problem, which there were not any. The P&O exam was given to 33 students. A post-exam survey was administered to measure students' perceptions (See Appendix C).

4. RESULTS

Students who took the P&O exam (n = 33) were ask perception questions on dimensions of the following: enjoyment (hedonics), ease of recall, metaphoric learning, test anxiety, relatability, and preference for format (Appendix C). Of the students, 22 agreed or strongly agreed that the story was enjoyable (mean 3.8/5 Likert scale, n=33). Most students do not have a preference on the type of exam (mean 3.5/5 Likert scale). A subset of students reported a strong preference as indicated by selecting "strongly agree" to "I wish more of my tests were presented like the George Washington [folklore]" (n= 8/33). Two students expressed a strong preference against the folklore exam ("strongly disagree", n=2/33). None of the students reported test anxiety increasing and 11 of the 33 students reported test anxiety decreased. The story did not add confusion to the exam process. The George Washington narrative neither helped nor hindered recall (3.4/5 Likert scale), perhaps because the narrative was only introduced at exam time. Using a story during learning and exam time may benefit student's recall.

5. DISCUSSION

Folklore-based learning can be an effective and fun method of presenting content for learning. The instructor crafts a story with embedded problems to be solved. The learner explores the problems and solutions through the main characters of the story. There are many examples of using narrative and folklore-based learning to replace a traditional lecture-based pedagogy. We extend the use of narratives into the assessment phase of pedagogy. The purpose of this research was to identify the uses and principles of narrative learning, discuss how to apply those principles into assessment exams, and demonstrate two examples of the said exam.

We refer the reader to Zazkis and Liljedahl (2009) who present a detailed how-to guide for writing learning stories: plot, conflict, imagery, human meaning, sense of wonder, humor, and

patterns. The same skills can be applied to writing a narrative exam.

As researchers and educators, we reflect on the needs that led to creating our narrative exams. Each year, faculty teaching the MIS and P&O courses write a post-semester reflection as part of our processes of assessment and continuous improvement. As a procedure to track assessment for our program's ABET accreditation, an analysis of those reflections led to the following conclusions. The MIS course was habitually rated low by students and not valued by other college of business faculty. Students did not value the content and frequently reported boredom with the course. This boredom and lack of engagement had impacts on learning retention. Further, the course was mainly textbook-based where students read chapters in a publisher's textbook, attended lectures, and were assessed via traditional multiple-choice exams.

In response, we redesigned the course content to be more relevant to student's needs, particularly those more relevant to the tasks they would encounter in the first five years of their post-graduate employment. The learning objectives were also redesigned to align with the other courses in the college's core curriculum. We abandoned the publisher's textbook and were not satisfied with other publisher alternatives. We also wanted more hands-on and experiential problem solving. As part of the changes, we adopted the Harvard Business Case, *The Adventures of an IT Leader*, which is an example of narrative learning (Austin et al., 2016). This case was successful at engaging students, holding their interest, and in removing some barriers and resistance to learning. As a natural extension, we designed a narrative exam. While success of the new MIS course cannot be solely causally assigned to narrative learning and assessment, those were important and prominent tools that helped improve the course. Regarding the narrative exam, one student commented, "That was the most fun exam I have ever taken!"

A second, narrative exam was created for the P&O course, including a post-exam survey. The folklore-based exam used in P&O course demonstrated that students accept the alternative exam format, did not find the change confusing, and enjoyed the exam. A subset of students preferred the folklore-based exam over a traditional exam. Some students report reduced test anxiety.

Potential advantages

The potential advantages to using narrative exams may be similar to those already attributed to folklore-based learning: increased cognitive focus and engagement (Green & Brock, 2000), increased perceptions of realism and application of the knowledge (Davidhizar & Lonser, 2003; Goldratt & Cox, 2016), and intuitively answering the students question of "why do I need to know this?" or "how would anyone use this?" We propose this type of exam may increase retention of knowledge because narratives and metaphors may increase salience (McGilchrist, 2019). Increased salience, according to the metaphorical connections made possible through storytelling and narrative, can be linked to increased recall. Storytelling in an exam may increase the hedonic response in the learning and assessment processes. The stories are disarming because they use familiar characters and themes (Robbins, 2006).

Returning to Narrative theory, humans are natural storytellers and learn through interpreting experiences. Narrative exams appeal to our affinity for stories. Stories can be leveraged to reduce resistance to learning and help the learner interpret experiences in the story to their own problem-solving experiences. The learner can identify with the characters in the story as they solve problems and, concomitantly, as the learner solves problems on the assessment exam. Through the process of metaphorical comprehension, stories increase retention of knowledge because the information has increased salience where this increase in salience is linked to memory (McGilchrist, 2019). This further aids in learners' perception that a new topic is less boring, more challenging, and more stimulating (Lee, Lee, & Lau, 2006).

In this section, we proposed potential benefits of narrative exams leaning on the existing literature regarding the known benefits of folklore-based learning. While we present preliminary results, these claims are yet to be substantiated and we encourage researchers to explore this potential and to quantify the benefits.

Potential challenges

Some challenges exist with narrative learning which may translate to assessment. The process is time consuming. Writing a story is an additional task after defining the learning objectives and writing the exam questions. Storytelling may not be among the instructor's strengths, particularly in a STEM field where the instructor's background may not have

emphasized these skills. New skills may need to be learned and practiced. New partnerships with those who are stronger at storytelling and writing may be needed.

When using narrative exams, instructors should consider impacts on anti-cheating mechanisms. Unfortunately, cheating is common in adult education. Multiple choice exams lend themselves to cheating because students can easily share questions and answers, particularly in online courses. However, this is not a new problem. Two possible methods for anti-cheating are: 1) to randomize the questions and, 2) randomize the order of the answers. With narrative exams, the questions cannot be randomized because doing so would break the flow of the single-plot story. Randomizing the order of the answers is still possible. Many content learning systems provide this feature.

The aim of this paper is to stimulate a new area of research. The contributions are the idea of a single-plot narrative used in an assessment exam, two examples of said exams, and a theoretical foundation using Narrative theory and metaphoric learning. We also discuss the potential challenges to using this approach and provide resources for instructors/researchers who wish to develop their own narrative assessments (i.e., Zazkis & Liljedahl, 2009).

Future study

Future areas for research may include the determination of the hedonic reactions of a narrative exam compared to traditional exams. Studies have shown that students quickly forget the knowledge learned in their courses. Can students retain and recall knowledge longer after a narrative exam? A mid-term offered as a narrative exam can be reevaluated as a final exam and compared to the results of traditional examination. Further related research questions are the following: Do students have greater focus and cognitive engagement during a narrative exam? Do our observed student perceptions regarding narrative exams generalize? Do students perceive problem solving through narrative exams as more applicable to the real-world? Can learning outcomes be improved with narrative exams in a manner that is commensurate with folklore-based learning? As exams are often associated with high anxiety, can narrative exams reduce anxiety and for whom? Because some students report that they are not good test takers, might narrative exams be perceived as more natural to real-world problem solving and help those who struggle with traditional examination methods? Future offerings of the MIS and P&O courses can compare a narrative exam to a traditional multiple-choice exam to explore these research questions.

6. CONCLUSION

There are many positive benefits to learning already demonstrated by using folklore-based learning. We encourage instructors to use more storytelling in learning. We encourage instructors to experiment with narrative exams. We further encourage researchers to explore perceptions of and causal relationships to learning afforded by narrative assessment strategies. The cognitive fit that metaphor-driven fables and folklores provide offers a compelling new direction to assist our learners.

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Appendix A: Example of a Narrative Exam

The following example is of an exam that uses storytelling. This exam was deployed in the management of information systems introductory course (MIS).

Learning Objectives
This exam assesses the following learning objectives relevant to the MIS course:

1. Students will be able to identify technology-based flatteners according to Tom Friedman.
2. Students will be able to distinguish types of collaborative writing technologies and workflows.
3. Students will be able to define the following terms B2B, B2C, B2G, C2C, or C2B.
4. Students will be able to recognize the application of a knowledge management system, knowledge discovery process, and of artificial intelligence in business.
5. Students will be able to recommend a technology for a given business need based on our in-class student technology presentations. Note: As a separate assignment, students researched various technology and then gave a five-minute presentation on the potential business application. This learning objective and related exam questions assess that learning was retained after the technology presentation assignments.

The answer to each question is identified with an asterisk.

Beginning of Exam
Read the following story and answer the related questions as if you were in the story.

You work for a consulting company called IBG, Inc. Your CEO calls you into a meeting with many other executives to discuss problems and solutions to the company's efforts. David starts by saying, "Thank you for coming. I was on the plane yesterday from Asia and read in a magazine article by Tom Friedman on how Toshiba has UPS does repairs for Toshiba customers. Toshiba customers request a laptop to be repaired. UPS picks up the laptop and takes it to a UPS warehouse where UPS employees fix the laptop and return it to the Toshiba customer without a Toshiba employee touching the product. This has costs advantages for Toshiba. I think Friedman called this brown sourcing. "

You laugh and quickly stop yourself.

David says to you, "What? Do you have something to say?"

You reply, "I'm sorry. I didn't mean to laugh. Permit me to correct the term. It's not brown sourcing. Friedman called the process _____"

Question 1. What term describes the process David is referring to (according to Tom Friedman's The World Is Flat)?

A. Offshoring
B. Insourcing *
C. Informing
D. Open sourcing

David replies, "Thanks for correcting me. I appreciate it and am not above correcting. Let's move on." He continues, "We need to write a business plan with our partners in Asia. Because they are in another time zone, we can't feasibly do conference calls to discuss the proposal. Instead, I want us to organize a team of writers and send the documents back and forth. Each person on the team will take a turn writing the proposal and then pass it on to the next person. Only one person at a time will be writing but I don't see any option. "

Question 2. Which of the following describes David's suggested method of writing?

A. Asynchronous writing *
B. Synchronous writing

David commented "I don't see any option, "referring to how to write where people each take turns. Joe asks, "But with everyone taking turns writing how will we know who made what changes and additions? I did this in college and it was a nightmare. I'd write a paragraph only to have someone else accidentally delete it and we didn't know. "

You offer a suggestion, "There is a feature in MS Word that can identify every author's contributions to the paper. It highlights any deletions or additions and who make the change. We can accept or reject people's changes when we are all done taking turns writing."
Joe asks, "That sounds cool! What feature is it?"

Question 3. You answer Joe's question of 'What feature is it?' with the following response:
A. Track Changes *
B. Insert Comments
C. Compare Documents
D. Restricted Editing

To the idea of how to organize a team of collaborative writers, you also suggest "Instead of taking turns writing, we could employ a different strategy. I learned in my CIDM3330 class that there are alternative strategies for organizing teams. For example, Jane is an awesome editor and grammaticist. Joe is very good with illustrations. Huyn is a good writer even though English is his second language and he knows the conditions in Asia so he can write about that. David knows the conditions in the US and can be a writer too. I can be a reviewer that reviews everyone's contributions because I use to be a peer-reviewer for a publication and it's my strength. This was everyone contributes based on their strengths rather than everyone doing every task."

David says, "I like that idea. I knew we hired a good person when we got you. What do you call that collaborative writing strategy?"

Question 4. You respond with, "According to the Lowry et al., paper (2009) that I read that strategy of writing is called _____."
A. Reactive writing
B. Parallel writing
C. Sequential writing
D. Group single-author writing
E. Stratified-division writing *

In the executive meeting, you just outlined some strategies for collaborative writing. David responds with "I like the idea." Joe response with "I like the idea to. I really like illustrations and graphic design but I don't like writing. But what do we do next? What are the tasks we do and in what order?"

You go to the whiteboard and write down seven common activities of collaborative writing and put them in the order of operation.

Question 5. According to the Lower et al paper (2009), put the following collaborative writing activities in order of which comes first, which comes second, etc., and which comes last.
A. Brainstorming *[Answers are in list order]
B. Converging
C. Outlining
D. Drafting
E. Reviewing
F. Revising
G. Copyediting

With the collaborative writing team organized the executive meeting moves to another topic.

Joe asks "David, with your meeting in Asia, is the Yoshi firm a B2B, B2C, B2G, C2C, or C2B?"

David replies "Yoshi firm primarily does B2B."

The new secretary fresh out of college leans over to you and quietly asks "What is B2B?"

Question 6. You respond with the following statement that defines the term "B2B"
A. Businesses are Yoshi's primary customers *
B. Consumers are Yoshi's primary customers
C. Governments are Yoshi's primary customers
D. Consumers selling to businesses

David, "Ok folks, we need to talk about our online marketing. We spent $1000 on Pay Per Click advertising and unfortunately it didn't produce good results. Any other ideas?"

Joe "I have an idea. Instead of paying for clicks we can pay for when prospects actually signup for a free trial of our product. Paying for the clicks just means someone saw our website but didn't actually do anything. This alternative allows us to only pay for when a prospect actually does something we want them to, like request a free sample of our product or sign up for one month trial. Website will advertise for us and we'll pay them for results not just visitors who browse. "

David, "Is it more or less expensive than Pay Per Click? We only paid 55 cents per click."

Joe, "55 cents is cheap, but the results were cheaper, after $1000 we only had one new customer. With this alternative, we do pay more, perhaps $5 to $10 per signup, but we get real prospects, not just curiosity seekers. And, with a lifetime value of each customer at $400, spending $5 to acquire new customers is a drop in the bucket. But I don't remember what this alternative to Pay Per Click is called?"

Question 7. You answer Joe's question with which of the following:
A. Article Marketing
B. Pay Per Action *
C. Pay Per Impression
D. Pay Per Click
E. Search Engine Optimization
F. Back-linking strategies

David, "Ok, so we need to help human resources communicate the new health insurance policies. Rather than sending 100 emails to all the employees what other ideas can we do to help the HR department disseminate information? "

Beth says "I remember in my MIS course at college that we had a topic like this. Let me remember. I forget the name of the thing, but it allows many authors to add content to a website. And all the company employees can visit the internal website to have their health insurance questions answers. We can even have comments areas for employees to ask questions. The human resource personnel can be authorized to add content to the site and the other employees can read and post comments and questions. HR people can write little articles and post them to help our employees know how to sign up for insurance, know how to take care of themselves, etc. If I can only remember what that was called?"

David, "HR is not technical. They don't have to know how to program a website do they?"

Beth, "No, not at all. We even did this in our course and you all know I'm not technical at all, but I don't remember the name of it?"

David, "Sounds great! Who knows what Beth is talking about?"

Question 8. What's the term that answers David's question?
A. Knowledge management systems *
B. Knowledge Discovery Process
C. Artificial Intelligence
D. Insourcing

David asks a follow-up question about collaborating with the colleagues in Asia, "We need to synchronize all the project files, photos, proposal documents, financial documents, etc. with our counterparts in Asia. I don't want to be emailing the documents back and forth because that's a sure way to lose a document or have it leak to the public. Any suggestions?"

Joe whispers, "I email my bank statements all the time without any problem." You kick him under the table.

You respond to David with "I have a suggestion. We can use a free software service that encrypts our files and stores them online. The company gives us free storage online for 2Gigs and we can buy more storage if we need it."

David asks, "But how does that help us?"

You continue, "When you download this software onto your computer it creates a special folder. Anything you put in that folder will be automatically synchronized with any computer that you share that folder with. You can even have it share and synchronize with your phone or iPad."

Joe exclaims, "But I'm an Android-tablet guy, not a Mac user!"

You continue, "It works and synchronizes your files with a PC, Mac, and many types of mobile devices, including iPhones and tablets. So, when I make add a project file to the folder, everyone on the team automatically gets the new file. If someone edits an Excel spreadsheet, the updated file is automatically synchronized with everyone. That way we keep all our project files in one folder and synchronized with the entire team. I saw a technology presentation on this method of collaboration and now use it frequently myself."

David smiles proudly and asks "Sounds good. What's the name of the technology?"

Question 9. According to the technology presentations seen in class, what is the name of the technology David is referring to?

A. DropBox *
B. Prezi
C. Team Speak
D. SmartThink
E. CCleaner
F. Monkey on Your Back
G. Sage Act
H. Smart Thinking
I. Windows' One Drive

To finish the meeting, David plugs his laptop into a projector, "I'll show you the prototype that our Asian counterparts have built." He fiddles with his Windows computer. His computer becomes unresponsive, takes a long time to open an internet browser, and David starts murmuring under his breath "Darn, stupid computer. Always slow. Why can't you work?" not realizing everyone can hear and see his frustration. You suspect he has problems with his Windows Registry and old programs causing his computer to be slow and unruly. You type a quick email to David on your iPad and recommend one of the following free software to help David tune up his computer.

Question 10. According to the technology presentations seen in class, what is the name of the technology that will help David?

A. DropBox
B. Prezi
C. Team Speak
D. SmartThink
E. CCleaner *
F. Monkey on Your Back
G. Sage Act
H. Smart Thinking

I. Windows' One Drive

Because of technical problems with David's computer, he defers the time to Joe. Joe gives an amazing presentation on the sales in Asia. The presentation is novel and inspiring, in part because he does not use MS Powerpoint. His alternative has stunning graphics and zooms into parts of the graphic, which displays his content. He even had an embedded video play. Everyone is impressed. As he sits down next to you, you ask Joe, "Awesome presentation. What did you use to create that?"

Joe responds "I used a free service on the internet called …" Bang! Crash! Just then someone drops several books and you didn't hear what Joe said.

Question 11. According to the technology presentations seen in class, which technology did Joe use?

A. DropBox
B. Prezi *
C. Team Speak
D. SmartThink
E. CCleaner
F. Monkey on Your Back
G. Sage Act
H. Smart Thinking
I. Windows' One Drive

END OF EXAM

Appendix B: Example of the George Washington Folklore Exam

This exam was deployed in a Productions and Operations course in a college of business. The learning objectives are to define various production terms, read and calculate values from a profit and lost statements related to productions/operations, and use linear programming to solve production problems.

BEGIN EXAM
You are on university campus and sit under a tree enjoying the nice Fall weather. You have a laptop to do your homework but decide to take a small nap. It's been a busy week. When you wake up, you are still under a tree but campus is gone. There is nothing but fields, hills, and more trees. The air is a bit more brisk and humid. "I don't think I'm in [City name] anymore," you say to yourself. Just then a man in old-time cloths and a musket challenges you, "Hey, who are you and what are you doing in General Washington's camp?" You slowly get up and explain that you are not sure. Seeing your strange cloths and laptop, he is suspicious and orders you to follow him to see General Washington. Everywhere you look around you see authentic gear and people from the American Revolution. Intuitively you know that something magical has happened.

You are escorted to a large tent with two guards outside. The sentry and you are admitted into the tent. The sentry explains how he found you. General Washington is a commanding figure and you cannot help but smile. General Washington

I know a thing or two about productions and operation. I own a plantation in Virginia. If you are telling the truth, you can answer a few questions. Tell me. What is direct labor? " General Washington proceeds to ask you to define some terms related to productions and operations.

Question 1. Answer General Washington's questions by matching the following terms to the appropriate definitions.

Direct labor: cost of labor involved in producing a product or giving a service.
Unit cost: is the total cost incurred by a company to produce one item of a particular product or service; does include variable costs and fixed costs incurred in the production process, but not include the sales process.
COGS: aggregate costs related to producing a sold product or giving a service delivered, includes cost of materials and cost of direct labor.
Overhead: costs that are not directly related to the production of goods or delivery of services (e.g., selling, administrative expenses, marketing and advertising costs, payroll tax expenses for non-production employees, legal and accounting fees, office supplies, etc.
Work in progress: Unfinished goods. The value of the material and direct labor for a product that is not yet completed, not ready for sale, e.g., a partially build wagon.
Operations: manufacturing processes that transform resources into products (finished goods)
Supply chain: processes that move materials to and from the firm
Efficiency: doing something at the lowest cost
Effectiveness: doing the right thing to create the most value

"Gentlemen," He says to his officers, "I believe our guest is telling the truth. I am an excellent judge of character and will attest for the correctness of the answers." Turning to you General Washington continues, "I don't know how you got here but perhaps you can give us some aid while you are here." You agree to help to the best of your ability.

"We have some capture documents from a Torri spy. We have some invoices, profit and lost statement. Perhaps you can help my quartermaster decipher some of the documents for useful information. Excuse me while I attend to other matters. "

The quatermasters name is Horatio Warren. You recall that a quartermaster is responsible for all the purchasing, requisition, and distribution of supplies and provisions for the army. Horatio explain that they intercepted an enemy supply of guns and ammunition that were being transported to the British Army. Upon investigating, the driver had secret documents in his position. "We are trying to figure the

gross profit margin so we can determine the sophistication of their supply chain." You review the profit and loss statement and calculate a gross profit margin.

Question 2. Given the profit and loss statement below, what is the gross profit margin? Enter a whole number, no decimals, no percent sign, no dollar sign or other symbols. For example, if you calculated a margin of 10%, just enter 10 into the box below. [Answer = 2000]

Profit and Loss Statement of Tory Alliance

Total Revenue	£	10,000
Cost of Goods Sold	£	2,000
Gross Profit	£	8,000
Operating Expenses		
Bribes	£	100
Rent	£	10
Total Operating Expenses	£	110
Operating Profit (EBIT)	£	7,890
Interest Expense	£	100
Income before taxes (EBT)	£	7,790
British Taxes	£	2,000
Net Income	£	5,790
# Outstanding Shares		£ 10,000
Earnings Per Share (EPS)	£	0.58

Horatio asks, "We are trying to figure the gross profit margin so we can determine the sophistication of their production operation." You review the profit and loss statement and calculate a gross profit margin.

Question 3. Give the profit and loss statement, what is the amount spent on activities directly related to products that were sold? Enter a whole number, no decimals or symbols. [Answer = 80]

You offer that it might help to compare the American's unit cost to that of this enemy's supplier. Perhaps the American army can learn if their manufacturing techniques are more efficient than the enemy's. The quartermaster agrees. Together you look through the documents and find the total number of muskets made and sold last quarter by the enemy supplier was 1200. The COGS for muskets was £ 3900 British Pounds during the same time period.

Question 4. Given the data presented, what is the unit cost for each musket in British Pounds? Enter only a number with no monetary symbols. Decimals are permitted. [Answer = 3.25]

"Wow!" exclaimed Horatio, "That's less than our unit cost. I wonder how they are producing muskets so cheaply. "

Horatio pulls a letter from his pocket. "I have a cousin Henry who is a patriot. He wrote me this letter asking for advice. Perhaps you can help us? He has 80 acres to plant crops. He wants to plant cotton and/or wheat to maximize his profits. He will donate the profits to our cause and support of this army. I want to tell him how to earn the most amount of profit. He must plant all 80 acres. He has a budget of £ 500 pounds. He only has enough cotton seed to plant 30 acres of cotton. He must plant a whole acre of one crop, no partial acres. Can you help? "

You withdraw the laptop from your backpack and Horatio looks on curiously. After a few minutes of data entry, you give him the answer to his cousin's question.

[Use Excel Solver to find an optimal solution given the set objective and constraints. Download and open the file Exam1.xlxs Worksheet Cotton. Then answer the following questions.]

Question 5: Given the cousin's problem, what is the set objective?

A. to minimize costs
B. to maximize profits [correct]
C. to set a value of
D. He has a budget of £ 500 pounds.
E. He must plant a whole acre of one crop, no partial acres

Question 6: Given the cousin's problem, what is the By Changing Variables?
A. He has 80 acres to plant crops
B. He wants to know how many acres of cotton and/or wheat to plant to maximize his profits. [correct]
C. He must plant all 80 acres.
D. He has a budget of £ 500 pounds
E. He only has enough cotton seed to plant 30 acres of cotton
F. He must plant a whole acre of one crop, no partial acres.

Question 7. Given the cousin's problem, what are the constraints? Select all the appropriate constraints.
A. He wants to know how many acres of cotton and/or wheat to plant to maximize his profits
B. He must plant all 80 acres. [correct]
C. He will donate the profits to our cause and support of this army
D. I have a cousin Henry who is a patriot
E. He only has enough cotton seed to plant 30 acres of cotton [correct]
F. He must plant a whole acre of one crop, no partial acres. [correct]
G. He has a budget of £ 500 pounds [correct]

Question 8. What is the recommended number of acres to plant cotton? [Answer = 80]
Question 9. What is the recommended number of acres to plant wheat? [Answer = 50]
Question 10. What is the total profit that can be earned by the cousin given the constraints? Enter a whole number with no decimals, no symbols. [Answer = 300]

Horatio thank you and starts to write a letter to his cousin with your recommendations.

Your attention becomes distracted when you overhear a heated debate between the officers and General Washington. You pause your work with the quartermaster to listen.

General Marquis de Lafayette animatedly says "The British under General Burgoyne are marching South from Canada to split the States. This is a grave threat. They will arrive at Saratoga and cross the Hudson River in 10 days. We need to stop their advance at the Hudson river near Bemis Heights. "

General Anthony Wayne responds, "We don't have any significant forces in that area. Our nearest forces are in Albany, Salem, and Fort Plain. Fort Plain has cannons with the strongest firepower. We

should send orders for them to immediate march with 50 cannons towards Bemis Heights. Taking Bemis Heights will give the advantage of high ground and maximum our strength. "

General Henry Knox fervently argues, "No. We should send General Gates from Albany. He has 1000 soldiers on foot. We need a large quantity of cheap soldiers. That will give us the maximum strength. "

General Lafayette shouts, "No. We must send cavalry soldiers from Salem. We have 200 cavalry. They can move the fastest and fight on horseback. They will give us the greatest strength. "

General Washington calmly replies, "Gentlemen. We need to be unified in our decision. We need to maximize the strength of army in order to stop General Burgoyne's British forces. We need to decide how many soldiers from Fort Plain, Albany, and or Salem to send. But we also need to be conscious of the cost associated with move our armies. We do not have unlimited funds to transport these soldiers. Our men are starving and ill-equipped. Every penny counts."

You boldly walk over to General Washington and say "Perhaps I can help. I've been trained in linear programming that can help find optimal solutions given constraints. I just need a bit more information." General Washington signals for you to proceed. You ask for the relative strength of each Continental army at Fort Plain, Albany, and Salem. You ask for the quantity of soldiers at each location. You ask for any constraints that need to be satisfied. From your various questions, the General provides you with the relevant information. You plug the data into your laptop and provide General Washington with a recommendation on how to deploy his soldiers.

[Use Excel Solver to find an optimal solution given the set objective and constraints. Download and open the file Exam1.xlsx Worksheet Washington. Then answer the following questions.]

Three Continental armies are within 8 days march of Bemis Heights where General Washington wants the combined armies to confront General Burgoyne. The Continental armies are located at Albany, Salem, and Fort Plain. How many foot soldiers, cavalry, and/or artillery batteries should be deployed to stop General Burgoyne? General Washington wants the strongest army possible. However, you cannot deploy more soldiers than there are available from each location. There is a total available budget of £ 1,300 pounds to transport the soldiers. No partial units allowed. Using the relative strengths given to you by General Washington, you establish hit points for foot soldiers, cavalry, and artillery.

[See the Excel file Exam1.xlsx Worksheet Washington for details. Find the optimum solution given the set objective and constraints. Answer the following questions regarding the General's problem.]

Question 11: Given the General's problem, what is the set objective?

A. to maximize the strength of the army [correct]
B. to minimize the cost
C. to set a value of
D. to minimize the number of foot solders deployed

Question 12: Given the General's problem, what is the By Changing Variable(s)?

A. Three Continental armies are within 8 days march of Bemis Heights where General Washington wants the combined armies to confront General Burgoyne.
B. How many foot soldiers, cavalry, and/or artillery batteries should be deployed to stop General Burgoyne? [correct]
C. However, you cannot deploy more soldiers than there are available from each location.
D. There is a total available budget of £ 1,300 pounds to transport the soldiers.
E. No partial units allowed

Question 13: Given the General's problem, what are the constraints? Select all the appropriate constraints.

A. There is a total available budget of £ 1,300 pounds to transport the soldiers. [correct]
B. General Washington wants the strongest army possible

C. How many foot soldiers, cavalry, and/or artillery batteries should be deployed to stop General Burgoyne?
D. No partial units allowed [correct]
E. However, you cannot deploy more soldiers than there are available from each location. [correct]

Question 14: What is the recommended number of foot soldiers to deploy from Albany? [[Answer = 150]
Question 15: What is the recommended number of cavalry to deploy from Salem? [Answer = 200]
Question 16: What is the recommended number of artillery batteries to deploy from Fort Plain? [Answer = 0]

You ask General Washington if you can borrow something to write with. He hands you his personal quill feather pen. You write down your recommendations and describe the strength of the resulting army. General Lafayette is interested in the concept of "hit points." You smile to yourself and think, "See mom, D&D wasn't a waste of time after all." General Washington thanks you with a sturdy handshake and expresses confidence in your answers. General Knox offers to draft the orders and the generals return to their strategic planning.

It is now late, and you are escorted out of General Washington's tent. Just before leaving, you look back at the noble General. He catches your eyes and nods his head. You see appreciation in his countenance.

You are assigned to bunk with the quartermaster and, exhausted from the day's adventures, quickly fall asleep. When you awake, it is light outside and you are sitting under the same tree as before. You see campus buildings as they should be. You think to yourself, "Did I dream that? Of course, I did. Meeting General Washington" and chuckle. As you start to put your laptop into your backpack you pull out a quill pen.

Question 17: Regarding the General's problem, what is the total army strength (in hit points) given the set objective and constraints? Enter a whole number with no decimals, no symbols. [Answer = 4750]

The End.

END OF EXAM

Appendix C: Survey Questions

Person
1. I enjoyed George Washington Fable
2. The George Washington Fable is enjoyable as narrative story
3. I don't enjoy George Washington Fable as it isn't serious (reverse coded)

Narrative
4.The exam used George Washington as a character in a narrative story
5.I can better recall a concept when it is delivered using a narrative story
6.The George Washington story was confusing (reverse coded)
7. The George Washington Story did not help me remember the material (reverse coded)

Metaphor
8.The George Washington Fable is a comparative story (a metaphor)
9. Comparative stories (metaphors) like the George Washington Fable helped me recall the concepts on the test
10. The George Washington Fable helped me relate to concepts in the examined material
11. The George Washington Fable does not help me because I cannot remember it (reverse coded)

Folklore
12. George Washington is considered a hero and great leader in American culture
13.Stories about George Washington are folklore because he was a great leader
14. Because I am familiar with George Washington the George Washington Fable helped me recall the concepts on the test
15.I believe everything I read about George Washington

Anxiety
16.The George Washington Fable reduced my test anxiety
17. Although I understand the story it is not possible to travel in time back to George Washington, the story made me feel at unease (reverse coded)
18. The George Washington Fable increased my test anxiety (reverse coded)

Context
19. I could relate to the linear programming question because the exam used muskets from the time of George Washington
20.The exam was progressively relatable as it used George Washington Fable throughout the exam
21. Because George Washington Fable was not believable, the questions were out of context for the exam (reverse coded)

Preference
22. I wish more of my tests were presented like the George Washington Fable
23. The George Washington Fable was not a useful way to present the material (reverse coded)

Are Professional Science Master's (PSM) Programs Beneficial for Graduates? An Evaluation of PSM Programs

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Abstract

Since the early 2000s, we have seen an increase in the need for graduates in various STEM fields. The Professional Science Master's (PSM) program was created in 2001 to address this increased demand. While research has shown the benefits these programs may provide, there is limited research examining the current state of PSM programs. The current research evaluates the perspective of students, alumni, faculty and program directors concerning the benefits from the PSM. Results suggest these programs still create competitive graduate students with concepts from the PSM being implemented in non-PSM programs.

Keywords: Professional Science Master's, Academic Quality, Graduate Programs, Graduate Skills.

1. INTRODUCTION

The Professional Science Master's (PSM) is a relatively new type of graduate degree which is "designed for students who are seeking a graduate degree in science or mathematics and understand the need for developing workplace skills valued by top employers." (2018, September 22 Retrieved from https://www.professionalsciencemasters.org/about). These programs prepare students to enter into a career in the STEM field. They are not intended to replace traditional degree programs but instead they focus on helping students acquire a deeper and broader level of scientific knowledge beyond a Bachelor's degree and apply those skills (National Research Council, 2008).

Prior to the creation of the PSM, a master's degree in many STEM fields was often seen as a stepping stone to a doctorate. In some cases, the master's degree is an undesirable path for doctoral science students who "master out" due to not being able to advance to doctoral candidacy. The PSM was designed to intercept those students that may not be interested in a doctorate, but those who are more interested in the practical and current research with immediate application in the workforce.

Among the fields included in PSM, there are few evolving faster than the area of computer science / information systems / information technology. This has made traditional curriculum development models difficult to follow. A unique challenge for these programs is having a structure in place that allows for continual collaboration with industry experts and modification of curriculum to seamlessly move students through the program and into the workforce with the skills that the industry demands at that time. This is very different than curriculum development and maintenance for other programs such as psychology or philosophy because of the innovative nature of technologies. By the time textbooks can become published, they are irrelevant and out of date.

According to the National Science Foundation (NSF), enrollment in science and engineering graduate programs are the highest they have ever been. As depicted in Figure 1, there has been gradual incline across all science and engineering degrees over the years, but none have made a gain like computer science, jumping from 25 thousand degrees awarded in 2014 to 32 thousand in 2015 (National Science Board, 2018).

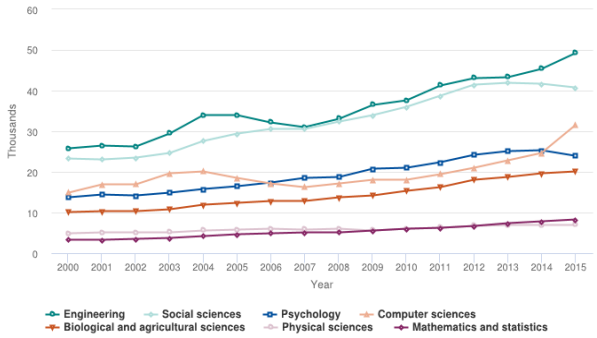

Figure 1. Science and Engineering Master's degrees awarded by field (National Science Board, 2018).

As demand continues to grow for graduates and the popularity increases in PSM programs, questions remain around the success of these types of programs. The research presented here aims to answer four questions:

RQ1: Are PSMs offering a competitive and relevant education?
RQ2: Are graduates of these programs immediately employable?
RQ3: What is the role that employers play in curriculum design and ongoing modification?
RQ4: Are graduates satisfied with the skills gained from the PSM?

The focus of the current research is in the PSM category of Computer Science / Analytics / Big Data / Statistics. This includes many programs that are a collaboration between computer science departments and information systems departments. By answering these questions, the research closely examines the processes surrounding program design of PSMs to ensure quality education for students, employability of graduates, and satisfaction of employers resulting in a more qualified workforce.

2. BACKGROUND

Backed by the Albert P. Sloan Foundation, the PSM initiative originated in 1997 as a number of universities focused on the integration of science and mathematics in new programs that crossed into management, law and other professional areas (Council of Graduate Schools, 2008). It wasn't until 2001 when a partnership between the Council of Graduate Schools (CGS) and Sloan began promoting the PSM initiative to various institutions offering master's degrees. In 2006, the CGS assumed full responsibility from the Sloan foundation and set the goal of making PSM a regular feature of graduate programs in the US (Council of Graduate Schools, 2008). As of 2018, there were 345 PSM programs, at 157 institutions, in 35 states, and 4 countries endorsed on the PSM website. (2018, September 22)

The National Professional Science Master's Association (NPSMA) is the membership association for the PSM initiative and was designed to further the PSM agenda of new programs and workforce alliances for PSM students and alumni. PSMs are unique combinations of rigorous study in science or math coupled with coursework in management, policy, or law. NPSMA delineates PSM programs as being designed collaboratively with industry experts, to provide a *science plus* curricula, which encompasses science content knowledge as well as the highly desirable business skills.

These industry experts, also referred to in this research as "employers", help develop the curricula, serve on advisory boards, and foster internships.

Another core characteristic of the PSM is the application of the skills learned during the program in the areas of science, technology, and business. This is approached in a variety of ways, though most commonly through internships, externships, coursework, and capstone projects. In a 2017 report published by the CGS, several recommendations were made to improve professional development (including graduate education) for science, technology, engineering and mathematics students including suggesting university engage more with industry through employer representatives, experts and alumni (Denecke et al., 2017). This is emphasized in many of the marketing materials for the PSM which informs employers that students experience applied learning opportunities and enter the workforce better prepared than traditional master's graduates. Students leave the program with STEM-specific skills as well as the professional skills needed to contribute to the scientific workforce upon hire. Table 1 below provides a comparison of traditional master's programs to PSMs.

Traditional master's	Professional Science Master's
Often stepping stone to PhD	Considered an alternative to PhD, a "terminal" degree
Thesis	Capstone
Theory-based	Application-based
Developed by university	University & Employer Developed
May or may not directly benefit local business economy	Designed to directly benefit local business through internships and direct hires

Table 1. Comparison of master's programs (from http://www.ncsl.org/portals/1/documents/Educ/09FallForumLynch.pdf)

For universities that are considering whether or not to start a PSM, there are guiding principles from the CGS which describe a feasibility determination as well as the core curricular elements which must include, "an experiential component that must include at least one capstone project, supervised collaboratively by faculty and employers, evaluated or graded by faculty and typically developed with an employer(s), which integrates the practical application of scientific and professional knowledge, behavior, and skills." (from the National Professional Science Master's Association, https://www.npsma.org/). While there is variation in how this is interpreted and implemented among institutions and programs, applied learning is a staple of the PSM programs.

Much of the research conducted on PSM has been through the Council of Graduate Schools (CGS) who were involved in the creation of this program. While they have shown a high employability rate of PSM graduates (Council of Graduate Schools, 2008), this was a pilot study conducted over 10 years ago. There has been limited research examining the benefits of PSM programs in recent years. Early criticism of PSM programs questioned the benefit of these degrees specifically around employability when compared to the cost of such programs (Russo, 2008).

The following study has several objectives achieved through the examination of multiple parties involved in these programs. PSM program faculty are surveyed to gain a better understanding of their role in curriculum design/modification. Survey questions seek to measure level of involvement with industry experts (employers) as well as level of satisfaction with the skills addressed in the program. Current PSM students are surveyed to measure how effectively the program is delivering the science and business skillset. Level of satisfaction is measured with current students. PSM alumni are surveyed and asked to evaluate how their skills gained as a result of the PSM, measure up in the workforce.

3. METHODOLOGY

The universities chosen for this study offer an official PSM and are endorsed on the Professional Science Master's website. The programs chosen all come from the Computer Science/Analytics/Big Data/Statistics category. Programs within this category include PSMs in the Information Systems, Computer Science and interdisciplinary.—The initial sample size of invited participants consisted of 15 universities.

Procedure

Initial contact with the universities began with the Program Coordinator listed on the Professional Science Masters website. Program Coordinators were sent an email describing the study and asking for their willingness to participate. Of the 15 universities invited, eight did not respond, three were unable or unwilling, one was willing but was too new of a program (it

did not have alumni or enough students far enough into the program to provide feedback). Thus, the final participants included two different universities.

The survey (via email) was distributed by the Program Coordinator to the students, alumni and faculty within the PSM. In addition to the surveys distributed, interviews were conducted with program directors. This was due to the limited number of universities participating. These qualitative results will be discussed later in subsequent sections.

Survey Development

The target populations of these surveys include program faculty, current students, and alumni. Items on the surveys ask the subject to indicate their level of agreement with a statement on a 4-point Likert scale. Additionally, open-ended questions were included in each survey.

The survey was designed using Kirkpatrick's four levels of evaluating training programs (Kirkpatrick & Kirkpatrick, 2006). In this framework, Kirkpatrick aims to guide program evaluation and subsequently instrument development by examining four levels:

Level		Description
1	Reaction	individual perceptions
2	Learning	knowledge, skills, abilities gained as a result of program
3	Behavior	ability to apply those newfound skills
4	Results	organizational change as a result of students applying those skills

Table 2. Kirkpatrick's Four Levels

The Kirkpatrick framework was chosen because of the wide application across academia and industry. The first level is focused on satisfaction, while the second level takes it a step further to assess whether actual knowledge, skills, and abilities (KSA) were gained as a result of the program. These two levels concentrate on individual impact. The third level aims to measure the ability to apply the KSA acquired in the program and the fourth level examines performance changes made as a result of those applied skills. These last two levels concentrate on organizational impact. For a list of survey questions used and how they align with the various Kirkpatrick levels, see Appendix A.

Pilot Study

Prior to data collection, the surveys were piloted with a small group of students, faculty, and staff. The pilot group was asked to read through the survey to ensure the questions were worded clearly, the instructions were thorough, and the functionality of the survey was intact. Members of the pilot group posed as stakeholders and completed the survey multiple times. Feedback was provided, and the survey was modified to increase readability and clarity.

4. RESULTS

The final survey was distributed across 2 universities for a total of 51 participants including students, faculty and alumni. The PSM at these two universities focused on computational science and data science/business analytics. The results are described in the subsequent sections separated by the quantitative and qualitative responses from participants.

4.1 Quantitative Results

Current PSM students and alumni were asked about reasons why students choose to pursue a PSM over the traditional master's program. The results can be found in Table 3.

	Students *(n=27)*	Alumni *(n=17)*
To develop highly-valued business skills	**55.6%**	**52.9%**
To increase opportunity for promotion, advancement and/or salary increase	51.9%	41.2%
"Real world" practical experiences	44.4%	35.3%
Advanced training to excel in science or math without a Ph.D.	40.7%	41.2%
Internship opportunity while in the program	33.3%	29.4%
Other	7.4%	17.6%

Table 3. Reasons for pursing a degree in a PSM program

Both current students and alumni agree on the top reason to enroll in a PSM program: to develop highly-valued business skills. In addition to developing valued skills, both students and alumni rated promotion, practical experience and advanced training without a PhD as being important. These results are similar to prior studies which alumni indicated their top three reasons for enrolling were: "(1) to acquire

specific skills and knowledge, (2) to learn more about something in which I am particularly interested, and (3) to increase opportunities for promotion, advancement and/or pay increases" (Komura, 2017). Other comments for pursuing a degree in a PSM program included networking, career change and gain additional/current skills.

Employability was another research question posed in the current study. Students were asked to predict how soon after graduation they would be able to find work. Alumni were asked to report how long it took them to secure employment after graduation. Finally, faculty were asked to report overall, how soon they observed graduates securing employment. Table 4 shows the employment expectations for current students and faculty. Also included is a column for alumni that reports the actual time it took to secure employment after graduation.

	Student *(n=30)*	Faculty *(n=3)*	Alumni *(n=17)*
Prior to graduation	**63.3%**	**66.7%**	**52.9%**
Immediately after graduation	30.0%	0%	11.8%
Within 6 months	3.3%	33.3%	17.6%
Within 1 year	3.3%	0%	5.9%
Longer than 1 year	0%	0%	11.8%

Table 4. Employment Expectations (Students & Faculty) and Actuals (Alumni)

There is agreement from all constituents that a majority of PSM graduates will have work lined up prior to graduation which is in agreement with how soon alumni were employed. Across all three groups of participants, over 80% of those surveyed agree that employment is expected (and actually occurred) within 6 months.

Additional questions were also posed to all participations concerning program satisfaction, workforce preparedness, and employer involvement (see Table 5 for results). Most alumni agree (either strongly agree or somewhat agree) with the statements that address program satisfaction and workforce preparedness. Faculty agree (either strongly agree or somewhat agree) with the statements surrounding workforce preparedness. However, there was slight disagreement with the statement that the program addresses industry needs.

	Student *(n=30)*	Alumni *(n=18)*	Faculty *(n=3)*
I am satisfied with the degree to which this program addresses industry needs.	3.13	3.33	3
I possess the knowledge, skills, and abilities desired by employers as a direct result of being in this program.	3.10	3.28	3.33
I feel prepared to enter the workforce and apply the knowledge, skills, and abilities that I've gained in this program.	3.20	3.35	3.66
This program affords me opportunities to interact with industry experts (potential employers).	3.03	N/A	N/A
The faculty in my program frequently communicate and collaborate with industry experts.	3.31	N/A	N/A
Likert Scale (4=Strongly Agree, 3=Agree, 2=Disagree, 1=Strongly Disagree)			

Table 5. Satisfaction, Preparedness and Employer Involvement.

Faculty were also asked to rate their level of agreement with three statements regarding students as change agents, collaboration with employers, and programmatic change. All faculty agree (either strongly agree or somewhat agree) with the statements about students as change agents and programmatic change because of interactions with employers. However, there was slight disagreement with the statement about opportunities to collaborate with industry professionals. This suggests that PSM programs need to work on involving more industry professionals within the program.

The PSM is touted as a terminal degree and an alternate way to remain in science without a Ph.D. Both current PSM students and PSM alumni were asked about intentions to pursue a doctoral degree. In both audiences, the majority do not intend to pursue doctoral studies. This data also shows the longevity of this viewpoint. Current students, given their experiences within the program and interaction with industry, do not feel as though they will pursue doctoral studies after graduation. For alumni, once out of the program and into the workforce, the belief remains the same.

4.1 Qualitative Results

The surveys contained several open-ended items to allow for qualitative responses from participants. Current students, alumni, and faculty were all asked to list 2-3 skills that are highly sought after by employers that are currently part of the program. Responses fell into the categories below (the number for each category refers to number of responses, not number of people):

Current Students

- Data Analytics/Visualization/Storytelling (10)
- R (7)
- Machine Learning (5)
- Python (5)
- Business-Related Skills (4)
- SAS (4)
- SQL (4)
- Applied Mathematics/Statistics (2)
- Programming (2)

Alumni

- SQL (6)
- Data Analysis/Visualization (4)
- Python (4)
- R (4)
- Tableau (4)
- SAS (3)
- Statistical Modeling (2)

Faculty

- Technical Skills (2)
- Communication Skills (2)
- Collaboration Skills (2)

There is agreement across all populations that technical skills including programming such as SQL, SAS, R, and Python be present in the PSM and are highly desired by employers. Data analytics and visualization were specifically mentioned by students and alumni, but not by faculty; although by listing "technical skills", this could easily encapsulate data analytics and visualization.

Current students, alumni, and faculty were also asked to list 2-3 skills that are missing from the program which they would like to see taught in future classes. Responses fell into the categories below. Responses that could not be categorized (i.e., were not similar to at least one other response) are not included. The number for each category refers to number of responses, not number of people.

Current Students

- Python (4)
- More Computer Science Courses (3)
- More Introductory Programming Courses (3)
- Big Data Technologies (2)
- Deep Learning (2)
- Statistics (2)
- Taking Project Through Entire Life Cycle (2)

Alumni

- Specific Language/Tool (10)
    - C++
    - D3
    - Java
    - Node.js
    - Non-SQL Solutions
    - Python
    - R
    - SQL
    - Tableau
    - VBA
- More Programming Courses (4)
- Communication/Presentation Skills (2)

Both current students and alumni agree that the PSM should include more programming courses. This is a fair request since all PSM students do not enter the program with an undergraduate computer science background. However, PSM programs in the Computer Science/Analytics/Big Data/Statistics category must teach some programming to teach the subsequent skills on which programming knowledge is based.

4.3 Program Coordinator Interviews

Because of the limited response to the survey, additional interviews were conducted with past and current program coordinators to get a deeper understanding of their perspective surrounding the PSM. Five interviews were conducted representing four large, public universities. The sampling of interviewees consisted of a former department chair, directors (past and present), program coordinators, and a dean of the graduate school; all with 3 to 15 years of experience in leading a PSM program.

The first question asked was, "During your time as the director, have you made any major

changes to the program?" The responses were as follows:

- Update curriculum
- Make changes based on labor market analysis
- Staffing changes made for additional support with leadership and advising
- Adding online courses to the curriculum for remediation purposes
- No major changes, program was new and still in implementation phase

As program coordinators were discussing previous changes, pending or upcoming changes were mentioned. These include:

- Develop a stackable core of courses. Then students can branch off into various tracks of data science: criminal justice, public policy…etc.
- Develop one group to oversee all changes. This is a separate, and larger, group from the advisory board but one that all curriculum and process changes can hopefully move more easily through with representation from both departments
- Add a project management component to the coursework

Next, they were prompted to describe some of the successes found in collaborating with industry experts (employers) and any changes made to the program as a result of that collaboration. The responses varied yet all PSMs interviewed mentioned their advisory board and how it has helped stay in touch with industry. Some of the responses received are listed below:

- The advisory board pushes the university to grow
- The nature of the program draws students that have 3-5 years of business experience which brings a different set of questions and insights
- Connecting with thought leaders from energy, healthcare, entrepreneurial endeavors, and motorsports

However, some shared concerns in collaborating with employers such as employer requests for a specific tool or software to be taught in classes. Knowledge and experience with this tool or software would mean the ability to "hit the ground running" when entering the workforce with little to no training. While this feedback is important in the broader sense, faculty do not want to design a course around what one particular employer has requested. One program coordinator gave the example, "I can teach a class on Amazon Web Services if it is a special topics class. But if I wanted to teach about cloud computing, I would only mention Amazon Web Services in addition to other solutions." Faculty want to ensure that students have a variety of skills and are aware of the principals behind them. Students should leave the program equipped with enough skills to appeal to the broader job market as a whole.

Another question asked, "What types of challenges have you encountered in facilitating an interdisciplinary PSM?", was often met with a thoughtful pause, and then deep explanation of several challenges. These include, but are not limited to:

- Silos within the university
- Trying to put forth any change. Too many separate groups of approvals, two deans, two sets of faculty (for those sharing a PSM across different departments/schools)
- Identity. Faculty positions have a "home" in one department, physical location of classes gives a geography division, not a "center" for the program if housed in two colleges
- Operational pieces are challenging
- Degree-specific course enrollments are often registration roadblocks and priority is awarded to students in those majors, not ours

Finally, program coordinators were asked, "What types of trends, in research or practice, have you seen in the PSM organization? Where do you see PSMs going moving forward?" The responses are as follows:

- New programs are broadening the PSM model to other science-based curricula such as biotechnology or earth resource management. I don't think these would have fit with the early definition of PSM.
- There is an issue of sustainability. At first, there was national support for PSMs but now that universities are on board, it doesn't seem worth the trouble of getting the affiliation at the national level when we can just do it on our own.
- Instead of the all-or-nothing model of either you affiliate with the PSM or you do not, there should be tiered levels of affiliation. This may allow for more to affiliate that would have otherwise not.
- The PSMs went from Sloan Foundation to Council of Graduate Schools to Keck Graduate Institute. There was a lot of initial growth but then stagnant for last 8 years or so. There needs to be more visibility on the national level.

4.4 PSM Affiliated Universities vs. Non-PSM

These interviews prompted a tangential research question to emerge, "Are universities conducting PSM-like graduate programs on their own without the national affiliation?" First, an examination of the number of PSM programs worldwide needed examining. Figure 2 illustrates the number of PSM affiliated programs (from all content areas) from inception to 2017. From an overall perspective, there *is* growth over time. The most dramatic growth occurred between 2008-2010 where the membership nearly doubled. This is likely a direct result of the 2006 legislation, the 21st Century National Defense Education Act (NDEA-21), discussed earlier. Growth in the latter years begins to taper off. While an upward trend is evident, it appears to be growing at a lesser rate.

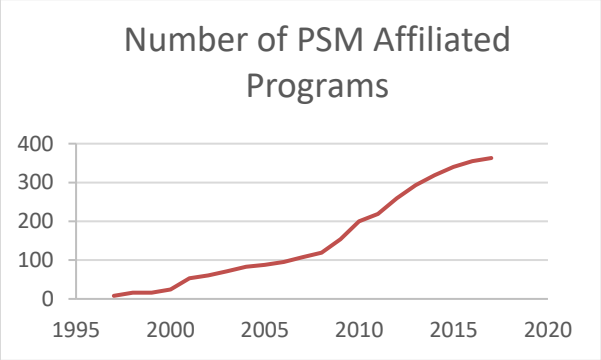

Figure 2. The number of PSM affiliated programs from 1997-2017.

A closer look at this data in comparison with the number of master's degrees conferred (in all content areas) is depicted in Figure 3. The National Center of Education Statistics aggregates and publishes the number of master's degrees conferred. The number of degrees awarded is steadily increasing. Figure 3 also displays the PSM programs available nationwide, increasing but slowing growth and dipping under the trend line (not shown). Over the ten-year period shown, the number of master's degrees conferred continues to rise at historical rates, while the number of new PSM programs rate of increase may be decreasing. Future research could show whether or not this trend will continue or if the number of PSM programs will decrease over time.

Finally, to understand how these types of programs compare to traditional master's, a detailed comparison within a state system (i.e., the North Carolina System) was undertaken to examine the importance of these programs in a more detailed analysis. Of the 16 universities in the North Carolina system, 609 degrees were considered to be from traditional master's program while only 21 (or less than 4%) were affiliated with a PSM program. The university with the most PSM programs is North Carolina State University with 8 PSMs available, roughly 8% of their programs. Only half of the universities in the North Carolina state system have a PSM available to students. Further analysis at a sample of universities suggest some master's programs follow the philosophy surrounding PSM but are not officially affiliated with the program. More discussion about these findings are included in the subsequent, discussion section.

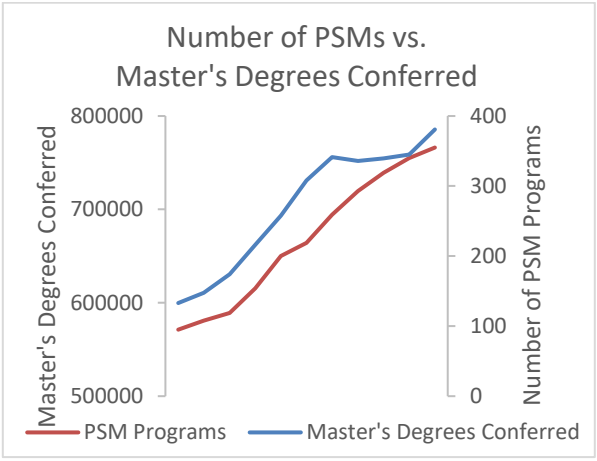

Figure 3. The number of PSM programs vs. master's degrees conferred 2006-2016.

5. DISCUSSION

PSM programs work strategically with industry professionals to collaborate, develop and revise curriculum, and matriculate students into the scientific workforce. The research question, "Are PSMs offering a competitive and relevant education?" can be answered with a resounding "Yes". Each program coordinator interviewed spoke highly of the advisory boards and processes in place which ensured the curriculum is continually being evaluated with industry experts. This research has shown that PSM graduates leave the program feeling marketable and employable with their skillsets. This research has revealed that PSM alumni reflect on the skills learned in the program and feel prepared to enter the workforce.

Employability is another significant factor for becoming a PSM program. This research question was addressed through the survey as well as interviews with program directors. Survey results supported employability with over 80% of alumni stating they either had

employment by graduation or within 6 months. During the interviews, one program coordinator explained that anyone with decent tech skills is easily employable and can find work in a variety of industries. Another program coordinator was explaining the 100% placement rate advertised on the program website and went on to say, that there is no issue with students finding employment- in fact they have the opposite problem- students often find employment and struggle to finish out the program. This is due to the high level of interaction between employers and students. Events where students can have poster sessions explaining their research often puts them in a positive light to employers and makes for an informal job interview.

While each institution adopts the PSM model in their own way, the advisory board is a staple of the PSM. Through interviews, this research question, "What is the role that employers play in curriculum design and ongoing modification?", was answered. Program coordinators described annual or bi-annual meetings with an advisory council, advisory board, or executive board whereby input from thought leaders in the industry helped to shape the program moving forward.

Finally, the satisfaction questions on the surveys sent to students and alumni directly addressed the research question, "Are graduates satisfied with the skills gained from the PSM?" Students and alumni alike were overwhelmingly positive about their experiences in the PSM programs. Students specifically mentioned skills acquired during the program that they felt would benefit them in the workforce. Alumni reflected on the skills gained during the PSM that gave them an advantage over their colleagues.

As previously mentioned, the interviews with program coordinators prompted a deeper dive into the number of PSM programs vs. traditional master's programs being offered in the North Carolina system. A close analysis of the university websites to determine how these non-PSM programs are operating illustrated that the PSM model has been widely adapted. Appalachian State University's Technology Master of Science website defines its industry and community involvement to potential students as, "All departments are highly involved with their industry counterparts and seek opportunities to work with community partners. In addition, each department has an advisory board of industry professionals that assist in program development, internships, job placement and fundraising." (Appalachian State University, 2019). The University of North Carolina at Greensboro describes in a flyer for the Master of Science Information Technology and Management program how, "…faculty sponsors industry groups which enables them to maintain close linkages with the IT industry and local businesses" (Department of Information Systems and Supply Chain Management, 2019). The Master of Science in Computer Science and Information Technology at Winston-Salem State University has a curriculum that, "provides students who seek a master's degree in a technical field the benefit of completing a program designed with a unique pedagogic composition—the combination of a traditional computer science core with applied courses in information technology. This combination develops a skill set for the application of computer technology resources to solve a variety of information need problems. Additionally, this program develops communication and leadership skills required in the corporate/government sector" (Winston-Salem State University, 2019). All of these are quintessential PSM features; advisory boards, applied learning, science + business curricula. However, none of these programs described are official PSMs, but they are all implementing core PSM characteristics.

5.1 Limitations

This study has potential limitations. Determination of the sample size of universities ensured that computer science, information science, and other multidisciplinary PSMs were part of the study. However, with a limited number of universities agreeing to participate, the breadth of programs represented is limited.

Another limitation is the population of "current student" and that it could include someone in their first semester in the program, or someone preparing to graduate. During qualitative analysis, some participants mentioned being new in the program and listed skills they would like to see taught; despite not knowing if the skills could possibly be taught in later courses.

The employment results may be skewed as most are in the area of tech which is experiencing an all-time high in hiring with the digitization of more processes and workflows. Future research could parse this factor out to examine the employability of non-tech PSM fields.

Finally, exogenous factors are not considered in this research. These factors include but are not limited to: trends in higher education,

government funding, state of the economy, or PSM affiliation costs.

5.2 Future Work

Future research needs to be conducted to include a larger sample of participants. While the initial sample size of 15 universities seemed sufficient, future studies will be expanded to include all universities within a specific category to increase response rate.

While the focus of the current research is the examination of PSM programs, future research will expand on the comparison of these programs to more traditional master's programs. Academic research in master's programs has included curriculum development (Shah, Kumar & Smart, 2018) and comparisons of requirements/curriculum (Karsten, H., Topi, H., Brown, S. A., Carvalho, J., Donnellan, B., Shen, J., Tan, B. C. Y. & Thouin, M., 2015). There is still a need to understand how a PSM program may offer benefits (e.g., employability) compared to a traditional master's program.

Additionally, given the conclusion that many new programs have adopted the PSM model without affiliating with the PSM organization, further investigation into newly created graduate programs may be warranted. This could bring into question the benefits of programs officially affiliated with PSM compared to those that follow PSM methodologies.

6. CONCLUSION

PSM programs appear to be beneficial for all parties involved including the employers, university, department and students/alumni. Students receive a real-world application of science and business curricula, and universities are providing relevant graduate education, and employers can influence a funnel that will drive future employees through the door. Research indicates that PSM programs are necessary to sustain our scientific economy and compete globally. The PSM model is now widely adapted as programs become more interdisciplinary, applied learning opportunities increase, and active advisory boards collaborate.

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Appendix A. Survey Questions

Survey Question		Topic Measured	Research Question	Kirkpatrick Level
Student Question Block	S1A	Program satisfaction	RQ4	KL1
	S1B	Skills possessed	RQ4	KL2
	S1C	Workforce preparedness	RQ1	KL3
	S1D	Student/employer interaction	RQ3	
	S1E	Faculty/employer collaboration	RQ3	
	S2	Skills possessed	RQ1	KL2
	S3	Skills missing	RQ4	KL2
	S4	Reasons for PSM		
	S5	Doctoral intentions		
	S6	Time to employment	RQ2	
Alumni Question Block	A1A	Program satisfaction	RQ4	KL1
	A1B	Skills possessed	RQ4	KL2
	A1C	Workforce preparedness	RQ1	KL3
	A2	Skills possessed	RQ1	KL2
	A3	Skills missing	RQ4	KL2
	A4	Reasons for PSM		
	A5	Doctoral intentions		
	A6	Time to employment	RQ2	
Faculty Question Block	F1A	Program satisfaction	RQ4	KL1
	F1B	Skills taught	RQ4	KL2
	F1C	Workforce preparedness	RQ1	KL3
	F1D	Students ability to enact change in workforce		KL4
	F1E	Faculty/employer collaboration	RQ3	
	F1F	Programmatic change as a result	RQ3	KL4
	F2	Skills taught	RQ1	KL2
	F3	Skills missing	RQ4	KL2
	F4	Likelihood for new PSM		
	F5	New PSM name (if applicable)		
	F6	Collaboration done well	RQ1, RQ3	
	F7	Collaboration improvement	RQ1, RQ3	
	F8	Time to employment	RQ2	
Research Questions				
RQ1 - Are PSMs offering a competitive and relevant education? RQ2 - Are graduates of these programs immediately employable? RQ3 - What is the role that employers play in curriculum design and ongoing modification? RQ4 - Are graduates satisfied with the skills gained from the PSM?				

Lessons Learned from Launching and Advising a Student-run Technology Consulting Venture

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Abstract

Information Systems (IS) instructors are continually searching for new and innovative ways to engage students in authentic experiences that mimic the real-world. Previous research asserts that graduates are more prepared when they have hands-on learning opportunities that are linked to real external clients. Unfortunately, real-world projects can either be too small for a particular course, or more often extend beyond the academic calendar limitations set on courses. While many institutions offer internship opportunities or student organizations for students to practice their skills, no curricular opportunities exist for students to run their own Information Technology (IT) consulting business. A private liberal arts institution piloted a course, through the generosity of the Coleman Foundation, to infuse entrepreneurship into the IS discipline; a subject lacking in many IS curricula. The course evolved into one of 14 student-run ventures on campus and is a going concern with over $15,000 in revenue to-date. Students are coached by a faculty advisor, manage the financial statements, run marketing campaigns, and engage in technical projects. Student consultants work on a variety of projects including, but not limited to web design, system analysis and implementation, and database management. The following paper represents the journey over the last four years to build a student-run, entrepreneurship-infused, technology consulting business model and venture, whereby students work *on the business* and *in the business*, concurrently, to support previous real-world projects from the classroom and seek additional client work.

Keywords: entrepreneurship, student-run venture, real-world, consulting, pedagogy

1. INTRODUCTION

It has been previously researched, practiced, and promoted that information systems (IS) programs produce more prepared graduates when they are engaged in hands-on learning opportunities (Abbassi & King, 2007). Furthermore, research also supports the engagement of external clients and real-world projects as effective means of engaging students in course content (Connelly & Begg, 2006). Even though real-world projects add value to the external client, there isn't always a support mechanism in place to resolve defects, make feature enhancements, or support the deliverable following implementation. The burden of support typically falls in the hands of the faculty or into a vacuum. In addition, real-world projects are typically bound by the academic calendar, which industry does not adhere to normally (Podeschi, 2016). These issues can be addressed through the infusion of entrepreneurship into the IS discipline. While entrepreneurship can often be found integrated into the business school, there is little evidence to suggest that it is being infused into IS (Pardede, 2015). However, IS programs within the business school are prime candidates for this marriage between IS and entrepreneurship. It has been cited that student-run venture experiences and collaboration outside of their disciplines helps students gain additional experience and increases their knowledge and confidence (Morris, Kuratko, and Cornwall, 2013).

In spring 2016, a course entitled Technology Ventures was piloted to build a feasibility plan for a student-run IT consulting company following independent study work by two junior IS majors who formulated the idea. The course was funded through a grant from the Coleman Foundation, which was administered by the university's Center for Entrepreneurship. The IS faculty, designated as a Coleman Faculty Fellow, used the elective course for students to build the business model for how the consulting venture would operate. The student-run venture and one-credit course, Millikin University Performance Consulting, was officially launched in fall 2016 with six students, all of whom where IS majors. Students, through this for-credit experience, identify potential clients, enumerate requirements, provide estimates of work and cost, complete the work, and produce detailed documentation for knowledge transfer to the next group of students. Students utilize the Scrum agile methodology for organizing their work, are responsible for maintaining accounting records, managing performance metrics, engage in marketing and recruiting, and report to an advisory board. To date, the course has enrolled 36 distinct students (as the course can be taken multiple times), performed work for over 15 unique clients, and earned over $15,000 in revenue. The venture is now open to students from other disciplines in addition to IS majors to foster cross-discipline collaboration.

This paper provides a summary of the literature related to entrepreneurship in technical disciplines as well as real-world projects and its pedagogical implications. In addition, the course/student-run venture design will be shared along with student outcomes from performance evaluation data. Finally, recommendations and pitfalls will be shared for those interested in implementing a student-run venture at their home institutions. This research is important to IS educators who are seeking new real-world opportunities for their students, and are interested in using this example as a framework for their own development.

2. REVIEW OF LITERATURE

Entrepreneurship

Entrepreneurship definitions vary across the landscape and have evolved over time from a popular phrase to a practiced discipline in higher education. Schumpeter defined entrepreneurs as those who are innovators who implement change within markets through the carrying out of new combinations (i.e. "creative destruction") (1965). Peter Drucker saw entrepreneurship as the process for creating new resources or leveraging existing resources to create value (1970). Timmons considers entrepreneurship to be about creating something new where nothing existed before without regard for resources (1985). Babson College, known worldwide for its entrepreneurship-focused education, views entrepreneurship as a way of thinking, reasoning, and acting that is opportunity obsessed, holistic in approach, and leadership balanced (Montoya, 2010). Entrepreneurship researchers across time agree that the process involves the marshaling of resources to exploit new opportunities and is not constrained to the notion that entrepreneurship is simply owning one's own business.

Entrepreneurship can be seen as a mindset and is at the intersection of the perceived ability to achieve what is possible and future goals that involve change and innovation. The entrepreneurial mindset can be seen in seven specific characteristics: 1) passionately seek new opportunities; 2) look for the chance to profit from change and disruption in the way business is done; 3) create entirely new business models; 4) pursue opportunities with enormous discipline; 5) pursue only the best opportunities; 6) focus on execution; and 7) create and sustain networks of relationships (Morris, Kuratko, & Colvin, 2011). With a discipline that can be practiced and is interdisciplinary and not necessarily constrained to a specific domain, it provides an ideal canvas for integrating into the technical realm.

With its rise in popularity, the study of entrepreneurship has evolved and can often be found woven into the modern business school. "Entrepreneurship education has grown dramatically, as reflected in the increased student enrollment, formal entrepreneurship centers, intercollegiate business plan competitions, new entrepreneurship curricula and programs, and endowed chairs and professorships" (USDC, 2013, p. 6). While its study has crept into the IS and engineering fields, there is little evidence to suggest that it is being taught in tandem with technical skill development (Pardede, 2015). As such, IS programs housed within business schools are particularly poised to meet this gap through the intentional integration of entrepreneurship into IS courses. While future employers continue to seek new graduates, who have the appropriate technical skills and ability to work in teams, 16.9% of respondents desire employees to have entrepreneurial skills, according to the National Association of Colleges and Employers survey

(2018). Pardede noticed the intersection between information technology (IT) students and entrepreneurship as many graduates go on to work for small- to medium-sized companies; many of them startup companies in the technology industry (2015). Unfortunately, it is rare to find a school that teaches specialized entrepreneurship education for IS students (Read, Derrick, & Ligon, 2014), and is most often found in the general business curriculum (Morris, Kuratko, and Cornwall, 2013).

There are, however, a few prominent examples of entrepreneurship being woven into IS programs. An early example included the development of a dial-up internet service provider at Boise State University (Minch & Tabor, 2007). Lang and Babb provide an argument and a framework for integrating entrepreneurship into IS curricula using Lean Startup and Scrum methodologies (2015). Faculty in Cal Poly Pomona built a student-run data center to run cloud applications for education (Hwang, Pike, & Mandon, 2016), and Frydenberg re-imagined the IS tutoring lab into a tech startup (2013). Others have developed specific elective courses focused on technology entrepreneurship (Jones & Liu, 2017). In business schools, there are a few examples of capstone/strategy courses being branded as student-run consulting companies (Robinson, Sherwood, & DePaolo, 2010; Ward, 2016). Yet, there are not examples of student-run consulting ventures that live in IS curricula.

Student-run Ventures

Student-run ventures differ from student-owned businesses or other tech startups initiated by students. Student-run ventures are formally owned by the university, can be profit-motivated or socially minded, and can be either co-curricular or integrated into a for-credit course. The advantages of integrating the venture into a course are a predicted stream of students, more structure, defined roles, documented processes, and more predictable outcomes (Morris, Kuratko, & Cornwall, 2013). Disadvantages of student-run ventures operating as part of a course include: insulation from true market forces and additional administrative overhead by faculty (Morris, Kuratko, & Cornwall, 2013). Millikin University, the author's institution, describes student-run ventures as "faculty led" and "student driven" with a definition of being learning laboratories as a course grounded in an academic discipline. At the time of writing, Millikin University has 14 student-run ventures embedded into courses across campus in theatre, art, music, physics, history, journalism, English, athletic training, business, and IS.

Real-world Projects

Real-world projects typically involve working with a client in the community or on campus to solve a particular business problem. Often, the project involves a not-for-profit organization or a smaller company that lack the technical expertise on staff (Schuldt, 1991). In some instances, especially with not-for-profit organizations, the project acts as a service learning component to develop the intentional act of giving back to the community (Chuang & Chen, 2013; Saulnier, 2005). Academic/industry partnerships through real-world projects and other means to ensure that what is taught in the classroom meets market demands and it provides other organizations with resources not normally available to them (Abbassi & King, 2007; Watson & Huber, 2000). The organization gains value from the student deliverable and the students gain practical experience that goes well beyond a structured lab exercise where the answers are predefined.

There are several examples from peer-reviewed research on the pedagogical value of real-world projects in the IS discipline (Abrahams, 2010; Helwig, 2006; Podeschi, 2016; Vaz & Quinn, 2014). Those pursuing degrees in technical fields rely on concepts and techniques, but employers find students more valuable when they have real-world experience (Chuang & Chen, 2013). Engaging in real-world projects allows students to practice both technical and non-technical skills. The National Association of Colleges and Employers found in their most recent employer survey that the top three attributes employers are seeking are written communication skills, problem-solving skills, and the ability to work in a team (2018). Providing a platform (student-run venture) for students to build technical and non-technical skills through real-world projects adds immense value to their educational experience and prepares them for a competitive job market.

3. COURSE DESIGN

The course was originally conceived by two IS students as an independent study project related to IS and entrepreneurship. The two students saw the student-run venture as a way to sustain client projects completed in previous IS classes, and a way to provide additional real-world experience to students in preparation for the job market. The Coleman Foundation had previously been funding this faculty member for infusing

entrepreneurship into IS, and this student-led idea provided the basis for extending that fellowship, with training and financial support, to build the student-run IT consulting venture.

The student-run venture was designed as a one-credit course that could be taken multiple semesters. This was done intentionally so that students could build competency and leadership while bringing consistency and institutional knowledge to the venture. Students perform technical services for existing clients which were previously started as real-world client projects from other IS courses. In addition, students seek new business from clients in the community and on campus. Students gather requirements, provide an estimate for services, a time line for completion, and manage each project end-to-end. They are ultimately responsible for the success and failure of each decision they make. The faculty serves as a liaison, buffer, and safety net for students as needed. When a project is complete, students have the client sign-off on the work and present them an invoice to be paid. Students pay themselves an hourly wage for work on client projects. All finances go through the university and students are paid through the university payroll office. Students reserve 50% of the prior semester's net profit for reinvestment into the venture. Their reinvestment can be spent on technology, conference travel, or wages to lead specific business-related projects.

The university assumes some level of risk knowing that students are performing work for external clients under the institution's name. All students sign confidentiality agreements at the beginning of the semester, and again with each individual client. In addition, students have language for documents such as scopes of work and project sign-off reviewed by in-house legal council. A year-end report is provided to the university's Center for Entrepreneurship on clients served, and financial statements are submitted to the university business office on a regular basis. In addition, the advisory board provides a forum for students to gain additional advice and expertise beyond the faculty's point of view. Between the faculty, the Center for Entrepreneurship, and the advisory board, there are sufficient checks and balances to ensure that students can experience real risk and real reward with a safety net in place.

In the original course design, enrollment was limited to IS majors. However, as roles became more defined and skill assessments were performed, it became apparent that a diverse set of disciplines were needed in the venture, just as is common in a typical organization. In 2018, the venture opened up to students who have taken Foundations of Information Systems, a course required by all business students, because majors outside IS are allowed to take the course. A typical semester has between 10 and 14 students enrolled. Each class meeting begins with a venture-wide Scrum, led by student leaders, to address the current status of client or business-related projects, set tasks for the next week, and address any roadblocks. Students are "coached" each week by the faculty during the later portion of class time and address timely topics specific to the client or the business operations. These topics can include, but are not limited to: learning the consulting process, working with difficult clients, budget forecasting, code review, or managing DNS. Guests with specific strengths are sometimes invited to help students work through acute problems.

Students begin as junior consultants in their first semester and are promoted to associate consultants the following semester (assuming a re-enrollment) after learning the operations and taking ownership of a specific process or task for the semester. This could be anything from taking meeting minutes to managing email and social media to building and maintaining the office computer equipment. Associate consultants work on client projects and perform operational functions for the venture. The faculty will appoint two or three senior consultants to lead client projects and operations of the venture for the semester. These are typically students who have been in the venture for multiple semesters, have internship experience, and have previously demonstrated leadership and organizational qualities. Senior consultants often continue as senior consultants if they elect to enroll again in a subsequent semester, but can be rotated out due to changing needs or poor performance.

While some client projects can be completed within the bounds of the academic semester, some continue from fall to spring or from spring into the summer months. Initial conversations with potential clients include time line requirements, and expectations related to response time, communication channels, and milestone objectives. Even though students earn credit for the course, they are also paid for their work. As a result, students will continue working on client projects when school is not in session with faculty supervision. Students have the ability to turn down a prospective client due to

unclear objectives, too large of scope, unreasonable time line, or if the client's project does not fit within the skill sets of the consultants.

Because the venture is dependent upon client work and can vary greatly from semester-to-semester, student consultants are evaluated in the course through means that mimic a workplace more than a classroom. Student consultants are charged with developing a set of goals for the semester. These can be technical in nature, non-technical such as verbal communication, or organization-related to advance a new initiative for the venture. Students must determine how they will measure their success in each of these goals, and report at the end of the semester, using both quantitative and qualitative methods, on how they met (or did not meet) their goals. Similarly, students go through two performance evaluations; one at midterm and one at the end of the semester. Students complete a self-evaluation and the faculty completes the same evaluation. The self-evaluation is asks students to rate themselves (on a scale from 1 to 5), in the areas of communication, job knowledge, work habits, quality of work, problem-solving ability, initiative, attitude and cooperation, adaptability, and leadership ability. Additionally students are asked to write a one-page narrative summarizing their performance and engaging in reflection. One-on-one meetings lasting approximately 10-15 minutes take place to compare the evaluations, provide constructive feedback on how to improve, and provide a forum for the student consultant to voice any concerns. Student consultants also complete a team evaluation to rate the quality of work of their peers. Student consultants report to an advisory board at the end of each semester, and occasionally reach out to them for mentorship throughout the school year.

From a pedagogical perspective, this student-run venture exemplifies two specific active learning frameworks. These include Kolb's work on experiential learning as seen as Table 1 (1984), and Merrill's first principles of instruction for effective and efficient instruction related to active learning as seen in Table 2 (2002). Kolb's learning theory, specifically, combines experience, perception, cognition, and reflection to create knowledge through experience; all hallmarks of real-world projects. Merrill's principles of instruction focus on the knowledge transfer from existing knowledge or new knowledge into the student-run venture, or in this case, creating an environment similar to that of a consulting practice.

Kolb's Required Elements of Experiential Learning	**Evidenced through Student-run Consulting Venture**
1. Include a concrete experience	1. Work on real-world client projects and perform business operations
2. Include abstract conceptualization	2. Requirements gathering, forecasting, project planning, and strategic thinking
3. Include active experimentation	3. New business models, different ways of tracking project progress, using different technology tools, and performing testing
4. Engage in reflection	4. performance evaluations, Scrum meetings, and client sign-off sessions

Table 1.

Merrill's First Principles of Instruction That Learning is Best Achieved When	**Evidenced through Student-run Consulting Venture**
1. Learners are solving real problems	1. Student consultants are performing real work for real clients, handling payments and expenses. They are running a business.
2. Existing knowledge is activated as the foundation of new knowledge	2. Student consultants use knowledge gained from previous courses (technical and non-technical)
3. New knowledge is demonstrated to the learner	3. Some projects involve skills not yet learned or practiced
4. New knowledge is applied by the learner	4. Student consultants select how business is transacted, and how work is completed for clients
5. New knowledge is integrated into the learner's world	5. Student consultants document their work into a knowledge base for current and future student consultants.

Table 2.

4. RESULTS

Over the past three years, students have earned over $15,000 in revenue and served 15 unique clients. Some of those clients return each semester for new projects or ongoing work. The course has enrolled 36 distinct students with a total enrollment over six semesters of 69 students. The maximum number of semesters a

student has been enrolled in the venture is four, while the average tenure of a student consultant is 2.03 semesters. As is the trend in technical disciplines, the gender balance skews towards male (80.5%) over female (19.5%). The diversity of students across majors beyond IS is represented in Table 3. Some majors like entrepreneurship and digital media marketing, as well as the entrepreneurship minor, require at least a semester in one of the 14 student-run ventures on campus, so this provides a forum for those students to experience work in the technical space.

Major	Number of Students
Information Systems	22
Digital Media Marketing	4
Mathematics	4
Accounting	2
Entrepreneurship	1
International Business	1
Music	1
Theatre	1

Table 3.

Student consultants have completed projects for clients that involve web design, network consulting, server/system implementation, database programming using Microsoft Access, data migration from Postgres to a cloud point-of-sale application, system analysis, design and recommendation, web application development in WordPress and Vanilla Forums, and mobile application development using PhoneGap and Microsoft PowerApps/SharePoint. In general, students gain client projects through word-of-mouth or actively seeking new work through their existing network of connections. In fall 2018, student consultants recognized the majority of their client work was web related. As a result, they decided to begin offering web hosting and support services and acting as the intermediary between the client and a third-party hosting provider. Students promote this as a value-added service to clients who don't have the expertise or interest in managing a website. Additionally, students manage all the financials using QuickBooks Online and coordinating deposits and checks through the university business office. They track projects using Trello and physically on a white board full of sticky notes. For communication, students use Slack with different channels for each client and have preferred it over traditional means such as email and group texts.

For the last four semesters, fall 2017 through spring 2019, students completed a team evaluation of their peers. Within that peer evaluation contained a section asking students to rate on a scale from one to five, one meaning never and five meaning continually, how often they practiced certain skills in their particular role of the venture. Within this collection period, 33 team evaluations were gathered. The skills ranged from technical to functional disciplines such as accounting and marketing, but also included essential skills like collaboration and presentation. In summary, 87.9% of students recognized that they practiced communication and collaboration either often or continually, project management (69.7%), and consulting (51.6%). System Analysis and Design is being practiced, in some form, by at least half the students (51.6%). However, 72.8% of students self-reported that they practiced technical skills either never or barely, accounting (66.7%), and legal issues (66.7%). When looking at the data set in totality (see Appendix A), it becomes apparent that someplace between 18% and 25% of students are working either in a technical or business discipline with a defined role, while between 39% and 70% of students are practicing essentials of communication, presentation, consulting, entrepreneurial thinking, and so on. The data show areas where students may need to be paying more attention such as legal risk and may also indicate that those working on technical projects may be individuals and not teams of student consultants. Furthermore, it may be concluded that either the majority of the technical work is being completed by the minority (rather than the majority) of student consultants or that the student consultants perceive some work as not being technical (e.g. system analysis and design, research and recommendation, web content updates). Further examination of what skills are being developed and practiced within the student-run venture is needed.

Students across all the disciplines mentioned above reflected in their evaluations on what the experience provided for them. Multiple IS majors stated that they learned how to work with clients better while increasing their technical skills on-the-fly rather than from a textbook. Additionally, students commented that the student-run venture forced them to learn and adapt as situations and requirements changed. One IS major said "I believe it gives me a huge step ahead with my major and learning how to deal with real-world clients will be important in my future internships and jobs." Another IS major learned that "you can't always rely on email to

communicate with individuals, and that sometimes you must use alternate methods like phone calls or physically visiting them." Math majors who were interested in IS commented that the experience provided them with more collaboration and team work that what was typical in their discipline. A digital media marketing major said "I worked continuously on trying to better understand how to market the student-run venture to our multiple target audiences and ways to engage our followers while sharing information about the business. This aspect of the business really showed me that you can't just post a picture on your social media that you find relevant and expect people to engage with it. You have to post eye catching pictures that followers want to see and create opportunities for them to engage." One MUPC alum working in industry, in particular, had this to say:

> "I think the best thing about being in a student-run venture is how it allows you to fail fast and learn from the experiences. For me, I think one of the biggest takeaways was simply working with a real client, facing real problems and coming up with a solution. The experience students gain from being in one of these ventures is the closest thing they will get to real life work experience. One big difference between a student run venture and the classroom is the overall environment. You're not just focused on completing assignment after assignment making sure you come out with a good grades, but having a real product to work towards. The value that a student run venture gives students, and gave me, is priceless. MUPC gave me the first glimpse of what it looked like to work in my profession, and I am grateful for that."

In general, students have had positive experiences from the student-run venture while preparing them for careers in their chosen disciplines.

5. RECOMMENDATIONS AND CONCLUSIONS

Starting and running and student-run venture admittedly consumes time from the faculty's perspective. In lieu of preparing for class lectures and grading typical work, the time is spent gathering progress reports from students, and following up with clients, if necessary. In general, it has been the faculty's perspective to engage with the client at the onset of the project and at the completion so that the student consultant must manage the process in the middle. The faculty solicits feedback from the client throughout the project and only intervenes when problems occur. It has been the purview of the faculty to act as a coach rather than a dictator. The senior consultants are the ones to take charge and direct the student-run venture on how to operate. Again, the venture is meant to be "faculty-led" and "student-driven." The faculty advisor is there as a safety net, but at the end of the day, students need to take ownership of their decisions, whether they are good or bad, reflect on them, and make recommendations on how enact change.

This experience works well for students who are highly motivated and interested in taking initiative. Developing a system for allowing high-quality students into the venture is an important aspect of ongoing success. In this particular case, it has worked well for current students to recruit new students into the venture. They oversee vetting and interviewing students to recommend for invitation, and are ultimately signed into the course by the instructor. Having proper evaluations instruments in place for checkpoints throughout the semester also provides a way to deliver corrective action for those who are under-performing.

As students work on projects for a client from semester-to-semester, it is imperative that students build documentation of their work for future student consultants. This is a challenge in the professional workplace, and it remains a challenge in this student-run venture as well. Not only are student consultants required to document their work, they are required to teach someone younger than them about the project. The two methods reinforce sustainability and strengthens the knowledge of the student consultant who worked on the project. Although students manage a Google Drive account for convenient access to files and data from the cloud, a dedicated office space is helpful to have for students to work on projects that require specialized software, to meet with clients, or to collaborate.

Additionally, students need to be given the opportunity to improve existing processes such as billing or social media or client communication. Part of working on the business and in the business concurrently is applying the entrepreneurial mindset of finding ways to do work better given the resources available while recognizing new opportunities. Students need the autonomy and permission to develop new streams of revenue, new markets, or research and develop their own IT solutions. Overall, the

student-run venture has provided and will continue to provide students opportunities to practice their disciplines in a real-world setting with real risk and real-reward.

Potential future research may include soliciting feedback from clients on their experiences working with a student-run IT consulting venture, and providing a guide on how students and faculty select clients. Additionally, since the university operates 14 student-run ventures, it would be helpful to devise a universal instrument to survey students across all the ventures to understand which discipline-specific, business, and entrepreneurial mindset skills are being exercised most and least. This may provide better insight into the overall effectiveness of student-run ventures and how to improve them for future student generations.

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Appendix A

Skills Practiced throughout the Semester					
Skill	**Never (1)**	**Barely (2)**	**Sometimes (3)**	**Often (4)**	**Continually (5)**
Technical	42.4%	30.3%	9.1%	6.1%	12.1%
System Analysis & Design	30.3%	18.2%	27.3%	15.2%	9.1%
Marketing	24.2%	24.2%	30.3%	6.1%	15.2%
Accounting and Finance	45.5%	21.2%	15.2%	6.1%	12.1%
Consulting	12.1%	15.2%	21.2%	21.2%	30.3%
Legal Risks/Issues	36.4%	30.3%	15.2%	18.2%	0.0%
Business Process Management	24.2%	6.1%	27.3%	27.3%	15.2%
Human Resource Management	33.3%	6.1%	21.2%	24.2%	15.2%
Project Management	6.1%	6.1%	18.2%	36.4%	33.3%
Collaboration and Communication	3.0%	0.0%	9.1%	27.3%	60.6%
Entrepreneurial Thinking	6.1%	9.1%	45.5%	27.3%	12.1%
Presentation	3.0%	9.1%	42.4%	30.3%	15.2%

Students' Perceptions of Challenges and Solutions to Face-to-Face and Online Group Work

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Abstract

Effective collaboration in small teams is valued by employers. Group projects can be a valuable experience in academics to apply knowledge, solve problems, and develop teamwork skills. Students frequently encounter group work in academic classes but are often not taught how to facilitate effective group collaboration and left to "figure it out on their own." Students frequently complain of group work because of bad past experiences. This research reports on two studies. In Study 1, business students (n=120) in a Management Information Systems course worked on a multi-week group project (4-5 students) and reported the challenges they experienced. Study 1 identified the types of problems students self-reported in group work and examined whether face-to-face and online students experienced the same problems. A survey and qualitative analysis were used. Result showed that students identified lack of communication, participation, collaboration, accountability, and interaction as the most common problems experienced. Study 2 (n = 129) attempted to ameliorate the problems by requiring the use of the communication software Slack and to improve accountability by using Google Docs to track responsibilities. The majority of students reported benefits from these tools. The list of the most common problems experienced is differed from study 1, indicating that the tools might have had a positive impact. The results showed that the proportion of students reporting problems in communication, participation, accountability, and interaction reduced significantly for face-to-face students with these tools but did not reduce for online students.

Keywords: group work, online learning, collaboration, small group communication

1. INTRODUCTION

Students learn best when they are actively involved in their learning process (Davis, 1993). In both face-to-face and online learning environments, instructors implement a variety of learning strategies to create meaningful learning experiences. One common instructional strategy used is group work. Group work is the collaboration of students working on the same learning goals. Implemented correctly, group work has been found to foster learning (Favor & Kulp, 2015; Kemp & Grieve, 2014; Lowes, 2014), help students apply knowledge (Elgort,

Smith, & Toland, 2008), encourage problem-solving skills (Canham, Wiley, & Mayer, 2012; Shimazoe & Aldrich, 2010), acquire greater communication skills (Oakley, Felder, Brent, & Elhajj, 2004), and develop teamwork skills among students (Brutus & Donia, 2010). Group work has been used in both face-to-face and online courses (Bonk, Lee, Liu, & Su, 2007; Ekblaw, 2016). However, implementing group work successfully, especially in online classes, continues to be a major challenge for instructors and students.

The purpose of this study was to examine students' experiences regarding group work in both face-to-face and online courses. Specifically, this research investigated group work in a Management Information Systems course. The results of this study may help instructors design group work that can increase student learning, success, and satisfaction.

The study addressed the following research questions:

1. What are the challenges that undergraduate students experience with group work in education?
2. Are there any differences in undergraduate students' perceptions of or challenges with group work when comparing face-to-face and online course delivery?
3. What ameliorations might have the potential to overcome the challenges undergraduate students face in group work?

2. LITERATURE REVIEW

Several studies found that online students dislike group work much more than face-to-face students (Favor & Kulp, 2015; Kemp & Grieve, 2014; Lowes, 2014). One study concluded that in adult learners, the attitude towards online group work influenced by prior negative experiences is unlikely to change regardless of how effective the current instructor or group is (Favor & Harvey, 2016). Roberts and McInnerney (2007) and Ekblaw (2016) summarized seven major challenges that impacted group work in both face-to-face and online environments. These challenges included:

- Student apathy towards group work. Students are not motivated or do not understand the benefits of group work.
- Selecting an appropriate process and the size of the group.
- Lack of group or social skills. Students often do not have the collaboration, management, or leadership skills needed to be an effective member of a group.
- Free riders are group members who do not participate yet receive the same grade.
- Inequality of student abilities within the group.
- Poor distribution or delegation of roles and responsibilities within the group.
- The fair or inequitable assessment of individuals within the groups.

Many of these challenges are interrelated. For example, student apathy can lead to free riding. Lack of group skills can lead to poor distribution of roles (Roberts & McInnerney, 2007). Additionally, Riebe, Girardi, and Whitsed (2016) noted that educators favored teaching content over process and tended to place students in teams with little or no instruction on how to work in teams. This was a major challenge to group work.

While most literature generally agrees on problems that can occur during group work, the solutions often diverge. Roberts and McInnerney (2007) attempted to provide a solution to each of the seven problems. However, some of the solutions may not be feasible such as creating an entirely new course focused on teaching group work skills. Ekblaw (2016) made a distinction between cooperation and collaboration. He defined cooperation as delegating tasks in parallel so that team members can work independently. Furthermore, he defined collaboration as the process of working on the tasks synchronously and collocated, which can be difficult to implement online. Ekblaw suggested that collaboration was more important to a successful group. Lowes (2014) researched online groups and found that delegating tasks in parallel was more effective than synchronous collaboration of group members.

Students are often most concerned about and motivated by their grade. Fairly assessing group projects has a large impact on students' perceptions of the success or failure of the project (Favor & Harvey, 2016; Roberts & McInnerney, 2007). Baugh (2017) attempted to solve the problem of assessing group projects by tracking student contributions. Students would log their specific work in a database. Then, the instructor assigned grades based 50% on the final group deliverable and 50% on the contribution of the individual student. Baugh

(2017) concluded that students liked tracking their contributions and preferred the visible level of accountability afforded by a database. Other researchers highlighted the use of peer evaluations for assessment (Favor & Harvey, 2016; Oakley et al., 2004).

Javadi, Gebauer, and Novotny (2017) used network analysis to compare face-to-face and online groups who used a discussion forum for learning. Their research concluded that online discussions closely resembled face-to-face interactions. Kemp and Grieve (2014) compared face-to-face and online communication in groups that were collaboratively writing. Their study indicated that online students registered more complaints regarding communication and indicated a preference to communicating face-to-face. However, the study also noted that there was no significant difference in academic performance face-to-face and online students, even though the online students complained more.

This research is built on prior research by investigating group work as defined by the following characteristics: small group sizes (4-5 members), collaboration over several weeks, and producing a written business document. This definition can be generalized to a business context where professional teams collaborate to produce a deliverable such as proposals, recommendations, business decisions, etc.

3. METHODOLOGY

Participants

Two studies were conducted. In both studies, the participants were undergraduate students at a regional university in the southern United States. They were enrolled in a junior-senior level, required Management of Information System course in a college of business with a typical undergraduate age range of approximately 20-30 years old with a few outliers. For Study 1, the survey was sent to 189 students. One hundred twenty students (face-to-face = 52, online = 68) completed the survey. Participants included 72 females (60%) and 48 males (40%). Participant's major included management (22%), general business (21%), finance (17%), accounting (16%), marketing (11%), computer information systems (9%), economics (3%), and business law and ethics (2%). For Study 2, the survey was sent to 152 students. One hundred twenty-nine students (face-to-face = 67, online = 62) completed the survey. Participants included 61 females (47%) and 68 males (53%). Participant's major included management (21%), finance (19%), marketing (17%), computer information systems (13%), general business (11%), accounting (9%), economics (4%), entrepreneurship (4%), and international business (2%).

Context

As part of the Management of Information System course curriculum, students completed a group project where they acted as an information systems consultant for a fictitious company. The goal of this assignment was for students to experience the analysis and design phases of the software development life cycle process (SDLC) and recommend a solution that involved an off-the-shelf, information system solution. The SDLC simulation was created by the professors who taught the course. The company had problems associated with growth: more employees than previously experienced, accounting inefficiency, over 90-day aging, errors in manual paper timesheet and payroll processes, desire to expand into new locations, desire to use social media marketing, interoperability problems, etc. The stakeholders, who were actors playing the role of owner, accountant, marketing director, and general manager, answered the following questions in a video. The video format was chosen to simulate a face-to-face meeting with stakeholders.

1. What do you do?
2. Please describe the problems you are facing and the associated business processes.
3. What are the negative impacts of these problems? What are the pains caused by these problems and can you quantify the negative impact?
4. How do you see the process changing if you could have anything you wish?
5. What requirements will your solution need to have? What constraints are you working under that we need to consider?

These videos were hosted on a website https://www.cis.wtamu.edu/simulation/.
Students were required to select the predefined interview questions as if they, the consultants, asking the question. The related video would play of the stakeholder answering the question. Students used stakeholder responses to identify problems in business processes, quantify the impacts of those problems, identify system requirements, identify any system or business constraints, and propose an IS solution. Students wrote this content into a 10-14 page proposal.

The group project lasted four weeks within a 16-week curriculum and included four phases. In Phase 1, students created their group profiles, communication plan, conducted the analysis phase, and identified the two business problems they wanted to solve. In Phase 2, students identified a potential information system solution and wrote about the IS in detail. In Phase 3, the professor met with each group to give feedback on the draft proposal. In Phase 4, students finalized the proposal, turned in the proposal, and completed peer evaluations. Three instructors taught the course. They all followed the same written course materials for the group project.

Data Sources

The data for both studies came from an online survey that was administered at the end of the group project. The survey for Study 1 consisted of demographic questions such as class standing and major and a question, "Check all the problems you encountered while working with your group this semester." Participants could select from sixteen predefined answers. Some of these were adapted from Koh and Hill (2009). The participants could also select "Other" as a response and free form an answer. Participants were also asked to answer an open-ended question, "Think about your overall current group experience in this class. What challenges did you encounter working with your group? Please explain." Participants reflected on the challenges they faced and wrote their response in short-answer form. The survey for Study 2 was the same as Study 1 with additional of question regarding students' perceptions of Slack and Google Docs. The "lack of communication" question was reworded to "communication problems among group members" to improve understanding.

Participants in Study 2 followed the same protocol as in Study 1, except that they were required to use a professional communication tool and a simple task management tool. Slack is a free, professional collaboration and communication tool (slack.com). Slack allows for file sharing and a log of conversation. This log enables the instructor to evaluate communication quality. Instructors can use the log generated by Slack to see which students are participating and which are not. Slack is available for mobile or web platforms. Students were also required to use a Google Doc to track who is responsible for which tasks modeled after Lean Six Sigma's Kaizen newspaper. This functionality can reduce miscommunication regarding who does what tasks and may add a level of personal accountability. The expectation was that with these tools the problems experienced by students in Study 2 will be lessened or different than in Study 1.

Data Analysis

Descriptive statistics were used to summarize the data. For the open-ended question, the authors coded the data as follows. First, the authors independently read the open-ended responses. The data were reviewed and analyzed using the constant comparative method (Glaser & Strauss, 1967). The authors then identified themes and categories related to students' experiences with the group project (Lincoln & Guba, 1985). Then, the authors compared, discussed, and agreed on the emerging themes until they all reached an agreement. A two-proportion, z-test was conducted in R to test if students experienced fewer challenges in Study 2 than in Study 1.

4. RESULTS

Results for Study 1 are as follows. In both face-to-face and online sections, lack of communication among group members was rated as the most frequent problem participants experienced (37% of face-to-face respondents reported having experienced a lack of communication, 32% among online students). Table A1 identifies all the problems students expressed (see Appendix A).

Other reported problems experienced by the face-to-face students were as follows: lack of participation from group members (35% of students expressed this concern), lack of collaboration among group members (33%), lack of accountability of group members (33%), and lack of interaction among group members (31%).

In the online sections, students reported other problems such as difficulty understanding the goal of the project (28%), lack of interaction among group members (26%), lack of participation from group members (25%), and lack of initiative from group members (25%). The open-ended question analysis supported the main finding that lack of communication was the most frequent problem experienced. We concluded that the face-to-face and online students largely experienced the same top challenges.

Results for Study 2 are as follows. Study 2 had students use Slack as a communication tool and Google Doc to track tasks and assignments. Online students and face-to-face students had different opinion regarding these tools. Regarding Slack's impact on group communication, face-to-face students rated "fair" or "poor" at 55% (n = 67). Online students rated Slack's impact on group communication as "very good" or "excellent" at 63% and "good" at 23% (n = 62). To the question "How did using Google docs to track tasks and due dates impact your group collaboration", face-to-face students reported "very good" or "excellent" at 73% and "good" at 18%. Online students reported "very good" or "excellent" at 56% and "good" at 24%. As the top five challenges experienced by students in Study 2, face-to-face students ranked the following: lack of my own time management (21% report experiencing this problem), communication problems among group members (16%), difficulty understanding the goal of the project (16%), lack of motivation (15%), and lack of participation from group members (13%). Online students' top five challenges differed: lack of participation from group members (48%), lack of my own time management (32%), communication problems among group members (29%), and lack of collaboration among group members (24%). Appendix B reports all the problems experienced by students in Study 2.

Using Slack and Google Docs as tools was predicted to lower the proportion of students experiencing top challenges that they reported in Study 1, specifically communication, participation, accountability, and interaction. These constructs were selected to study because they were rated as the top five challenges observed in Study 1, were common to both online and face-to-face students, and the communication tools in Study 2 were designed to solve these specific problems. To test for significant differences between the two studies, a two-proportion z-test was conducted to compare the proportion of students in Study 2 who experienced communication, participation, accountability, and interaction problems to those of Study 1. If the communication tools had a positive effect in Study 2, a reduction in proportion should be observed compared to Study 1 (See Table 1 and Table 2).

Table 1 presents the results of a two-proportion z-test comparing the proportion of face-to-face students who reported experiencing certain challenges. Proportions were significantly different in Study 2 than in Study 1, indicating that fewer students in Study 2 experienced communication, participation, accountability, and interaction challenges than in Study 1. We attribute this to the use of Slack and Google Docs in Study 2. The statistics are as follows: communication (X-squared = 5.3, df = 1, p-value = 0.01), participation (X-squared = 6.3, df = 1, p-value = 0.006), accountability (X-squared = 9.1, df = 1, p-value = 0.001), and interaction (X-squared = 5.3, df = 1, p-value = 0.01). See Appendix C for reproducible R code and data.

Table 1. Proportion of face-to-face students' challenges

Problem Experienced	% of Students in Study 1	% of Students in Study 2
Communication	37%	16%*
Participation	35%	13%***
Accountability	33%	9%***
Interaction	31%	12%**
Sample size	52	67

Note. The data is the proportion of students saying they experienced a particular problem. Test of significant differences comparing Study 1 to Study 2 is * p <= 0.05, ** p <= 0.01, *** p <= 0.001.

Table 2 reports the a two-proportion comparison for online students in Study 1 and Study 2. While a reduction in proportion is observed for some constructs, none of the constructs were significantly different.

Table 2. Proportion of online students' challenges

Problem Experienced	% of Students in Study 1	% of Students in Study 2
Communication	32%	29%
Participation	25%	48%
Accountability	24%	23%
interaction	26%	23%
Sample size	68	62

Note. No significant differences.

5. DISCUSSION AND LESSONS LEARNED

The purpose of Study 1 was to identify student perspectives, particularly challenges, they encountered with group work. The purpose of Study 2 was to try a treatment that could alleviate the problems experienced by students in group work. The type of group work included 4-5 person groups where students identified two business problems, recommended business

solutions to those problems using information systems, and wrote a business proposal.
The main finding of Study 1 was that students considered lack of communication with their group members to be their largest hindrance. There was no difference between face-to-face and online students. When students complained of lack of communication, they meant not having enough communication with group members, not having enough interactions, initiating communication at the last minute, conducting low quality discussions, experiencing lack or poor generation and evaluation of ideas, and having conflicts with their peers with no resolutions. Students chose texting as their technology for communication, and some students referred to texting as a poor tool for communication.

In some instances, the lack of participation by some group members led to a lack of communication in terms of quantity and quality. Lack of participation is distinguished from lack of initiative as follows: Initiative is defined as taking action independently without being assigned. Participation is being involved in the process regardless of whether the task was assigned by someone else or not. Conflicting schedules was another hindrance students experienced. Some students shared that they were busy with work and family. This impacted the availability and frequency of their communication. Findings also revealed that students experienced more problems during the first phase of the project than in subsequent weeks.

Study 2 attempted to ameliorate the problems experienced by students by requiring the use of Slack to communicate and Google Docs to track responsibilities. The vast majority of online and face-to-face students reported improvements in communication and to group collaboration because of Slack and Google Docs.

Students' report of the most common problems experienced were different than from Study 1. We interpret this observation as the tools having a positive impact such that the problems in Study 1 were reduced in Study 2 and new problems were exposed in Study 2. We observed the proportion of students reporting problems in communication, participation, accountability, and interaction reduced significantly for face-to-face students using the communication tools but not for online students. Online students, who may need the communication tools more than face-to-face students, did not seem to experience as great an effect even though their perceptions were that the tools were beneficial.

In Study 2, students ranked "lack of time management by myself" and "lack of time management group members" among their top challenges. This observation may mean that the communication tools had positive impacts on some challenges and exposed new weaknesses that future studies can help address.

Changes to future course offerings
Instructors may form group projects with the assumption that students know how to work in groups and do not teach group collaboration (Gueldenzoph Snyder, 2009; Riebe et al., 2016). As a post-reflective activity, we searched the literature for additional solutions to group collaboration challenges. Oakley, Felder, Brent, and Elhajj (2004) recommended using learning activities early in the semester to introduce group work skills before the group project. The three instructors did a similar activity where each group completed an activity on Slack. The purpose of this learning activity was to introduce students to each other and familiarize them with how to use Slack. Research also showed that practice exercises at the beginning of the course could foster group work and communication skills (Ekblaw, 2016; Roberts & McInnerney, 2007). Gueldenzoph Snyder (2009) reviewed business communication literature to identify team building exercises which could be adapted to academic learning.

Ekblaw recommended instructors assign functionary roles to each team member rather than letting teams figure out what needs to be done by whom. In online classes, Lowes (2014) recommended structuring the group project so that students could work on their parts asynchronously and independently. Students still cooperated but would depend less on synchronous collaboration.

Scarfino and Roever (2009) suggested a card game called Diversity as the activity which can help build communication skills. Gueldenzoph Snyder (2009) outlined a group learning activity as follows. In small groups, ask the students to discuss the pros and cons of group work. Ask students to discuss the purpose of the class project. Ask students to role-play positive collaboration, e.g., active listening, questioning, and restating techniques. Ask students to develop a timeline by reverse engineering a project. Train students to negotiate conflicts by asking students to role-play impartial methods to resolve any problem. This activity can be

done with online students via team collaboration software or discussion forums.

6. CONCLUSION

Group projects can be a valuable experience in academics to apply knowledge, solve problems, and develop teamwork skills. These skills are requested by employers. The instructors of this course opine that a subset of College of Business students have not learned how to effectively communicate in groups despite having taken two semesters of English classes and experiencing other group projects in other classes. Many students are not prepared for communicating or collaborating in real-world teams. Students identify lack of communication, participation, collaboration, accountability, and interaction as the most common problems experienced in group work.

We demonstrate that using professional communication tools can have positive impacts on collaboration. As educators, we have a responsibility and opportunity to help students overcome inter-group communication challenges. Doing so will give students a valuable skill to take into the workforce.

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Appendix A. Students' Problems from Study 1

Summarized data from the survey responses by students after experiencing the group project. The survey asked, "Check all the problems you encountered while working with your group this semester." Students could select from sixteen predefined answers that were adapted from Koh and Hill (2009). The students could also select "Other" as a response and free form an answer (see Table A1).

Table A1: Problems Students Encountered in Group Work

Challenge Description	% of Face-To-Face Students Expressing this Challenge (N = 52)	% of Online Students Expressing this Challenge (N = 68)
Lack of communication among group members	37%	32%
Lack of participation from group members	35%	25%
Lack of collaboration among group members	33%	22%
Lack of accountability of group members	33%	24%
Lack of interaction among group members	31%	26%
Lack of time management (group members)	29%	21%
Lack of understanding among group members	27%	24%
Lack of initiative from group members	27%	25%
Lack of time management (myself)	23%	16%
Difficulty understanding the goal of the project	21%	28%
Lack of feedback from group members	21%	16%
Lack of encouragement from group members	19%	15%
No problems encountered	15%	24%
Lack of a sense of community	13%	16%
Lack of feedback from instructor	10%	1%
Lack of group dynamics	8%	9%
Lack of leadership	6%	7%
Late to meeting	2%	N/A
Lack of motivation	2%	N/A
Confused about the project	2%	N/A
Difficult peer	4%	N/A
Different opinions	N/A	1%
Unequal distribution of tasks	N/A	1%
Too much leadership	N/A	1%
Miscommunication	N/A	1%
Communication method	N/A	1%
Problems with technology	N/A	1%

Note. The percentage refers to the number of students out of the total respondents for face-to-face or for online who expressed the complaint.

Participants answered an open-ended question, "Think about your overall current group experience in this class. What challenges did you encounter working with your group? Please explain." Participants reflected on the challenges they encountered and wrote their response in short-answer form. Researchers analyzed the responses into categories of problems (see Table A2 and Table A3).

Table A2: Challenges Encountered by Face-to-face Students According to Open-ended Responses (N = 52)

Challenge Description	% of Students Expressing this Challenge
Lack of Communication (e.g., lack of response or feedback from peers)	22%
Lack of Peer Participation	19%
Different Schedules (e.g., working adults)	13%
Lack of Accountability of Peers	7%
Poor Time Management	6%
Difficult Peer (e.g., peer who took over project, peer did not listen to other group members, difficult to reach agreement or consensus)	4%
Difficult to Meet	4%
Difficult to use consistent writing style/format	3%
Lack of Collaboration	3%
Lack of Understanding of Project	3%
Unequal Task Distribution	3%
Lack of Expectations	3%
Lack of Quality Work from Peer	3%
Group Too Big	1%
Burned out at the end of the semester	1%
Not using Google Docs	1%
Overall Organization of Project	1%

Note. A qualitative analysis of the open-ended question resulted in these themes

Table A3: Challenges Encountered by Online Students According to Open-ended Responses (N = 68)

Challenge Description	% of Students Expressing this Challenge
Lack of Communication (e.g., lack of response or feedback from peers)	34%
Different Schedules (e.g., different time zones)	24%
Lack of Peer Participation	18%
Lack of Accountability of Peers	9%
Time Management (Poor)	7%
Difficult to use consistent writing style/format	4%
Difficult Peer (e.g., peer who took over project, not being open to criticism, difficulty to reach agreement)	3%
Lack of Collaboration	3%
Figuring out how to delegate tasks	3%
Not Knowing Peers	3%
Lack of Motivation (Peer)	3%
Online Aspect	3%
Lack of Understanding of Project	1%
Unable to Meet In person	1%
Group Too Small	1%
Adapting to Peer Personalities	1%
Hard to Depend on Others	1%
Different Work Styles	1%
Having a Group Project in an Online Class	1%

Note. A qualitative analysis of the open-ended question resulted in these themes

Appendix B. Students' Problems from Study 2

Summarized data from the survey responses by students after experiencing the group project in study 2. Regarding Table B1, students explicitly selected predefined choices in the survey. The survey asked, "Check all the problems you encountered while working with your group this semester." Regarding Table B2 and Table B3, students answered open-ended questions about problems they experienced and the problems were categorized by the researchers.

Table B1: Problems Students Encountered in Group Work from Study 2

Challenge Description	% of Face-To-Face Students Expressing this Challenge (N = 67)	% of Online Students Expressing this Challenge (N = 62)
No problems encountered	24%	48%
Lack of time management (myself)	21%	32%
Communication Problems among group members	16%	29%
Difficulty understanding the goal of the project	16%	29%
Lack of motivation	15%	24%
Lack of participation from group members	13%	23%
Lack of collaboration among group members	13%	23%
Lack of time management (group members)	12%	21%
Lack of interaction among group members	12%	21%
Lack of understanding among group members	12%	18%
Lack of accountability of group members	9%	15%
Lack of initiative from group members	7%	15%
Lack of feedback from group members	6%	13%
Lack of a sense of community	6%	11%
Lack of leadership	6%	11%
Lack of encouragement from group members	3%	6%
Lack of feedback from instructor	3%	6%
Lack of group dynamics	1%	3%
Problems with technology	1%	2%
Maybe too long of time to complete 3 weeks would work easy	1%	2%

Note. The percentage refers to the number of students out of the total respondents for face-to-face or for online who expressed the complaint.

Table B2: Challenges Encountered by Face-to-face Students According to Open-ended Responses

Challenge Description	% of Face-To-Face Students Expressing this Challenge (N = 67)
No Problems	30%
Different Schedules (e.g., working adults)	9%
Lack of Communication (e.g., lack of response or feedback from peers)	7%
Lack of Peer Participation	4%
Poor Time Management	4%
Difficult to Meet	4%
Unequal Task Distribution	3%

Overall Organization of Project	3%
Different Work Styles	3%
Lack of Motivation	3%
Difficult Peer (e.g., peer who took over project, peer did not listen to other group members, difficult to reach agreement or consensus)	1%
Difficult to use consistent writing style/format	1%
Lack of Collaboration	1%
Lack of Understanding of Project	1%
Lack of Expectations	1%
Lack of Feedback from group members	1%
Different Work Styles	1%
Too Much Writing	1%

Note. A qualitative analysis of the open-ended question resulted in these themes

Table B3: Challenges Encountered by Online Students According to Open-ended Responses

Challenge Description	% of Online Students Expressing this Challenge (N = 62)
Different Schedules (e.g., different time zones)	27%
Lack of Peer Participation	24%
No Problems	18%
Time Management (Poor)	15%
Lack of Communication (e.g., lack of response or feedback from peers)	13%
Difficult Peer (e.g., peer who took over project, not being open to criticism, difficulty to reach agreement)	5%
Lack of Motivation (Peer)	5%
Lack of Accountability of Peers	3%
Figuring out how to delegate tasks	3%
Lack of Understanding of Project	3%
Technology Problem with Slack	3%
Technology Problem with Google Docs	3%
Difficult to use consistent writing style/format	2%
Lack of Collaboration	2%
Online Aspect	2%
Adapting to Peer Personalities	2%
Different Work Styles	2%
Having a Group Project in an Online Class	2%

Note. A qualitative analysis of the open-ended question resulted in these themes

Appendix C. Reproducible R Code and Data

The following is the data and R code for Tables 1 and Table 2 in the manuscript.

```
#data in raw counts. Number of students expressing they experienced these problems
study1f2f_communication = 19
study2f2f_communication = 11
study1online_communication = 22
study2online_communication = 18
study1f2f_participation = 18
study2f2f_participation = 9
study1online_participation = 17
study2online_participation = 30
study1f2f_accountability = 17
study2f2f_accountability = 6
study1online_accountability = 16
study2online_accountability = 14
study1f2f_interaction = 16
study2f2f_interaction = 8
study1online_interaction = 18
study2online_interaction = 14
#sample sizes, count of students surveyed
study1f2f_N = 52
study2f2f_N = 67
study1online_N = 68
study2online_N = 62

## Communication problems
#Hypothesis study 2's f2f proportion is less than study 1's
#results: confirmed significant. p =0.01
prop.test(x = c(study2f2f_communication, study1f2f_communication), n = c(study2f2f_N,
study1f2f_N), alternative = "less")

#Hypothesis study 2's online proportion is less than study 1's
#results: not significant. p =0.057
prop.test(x = c(study2online_communication, study1online_communication), n = c(study2f2f_N,
study1f2f_N), alternative = "less")

## Participation problems
#Hypothesis study 2's f2f proportion is less than study 1's
#results: significant, p = 0.006
prop.test(x = c(study2f2f_participation, study1f2f_participation), n = c(study2f2f_N, study1f2f_N),
alternative = "less")

#Hypothesis study 2's online proportion is less than study 1's
#results: not sig, p = 0.87
prop.test(x = c(study2online_participation, study1online_participation), n = c(study2f2f_N,
study1f2f_N), alternative = "less")

## Accountability problems
#Hypothesis study 2's f2f proportion is less than study 1's
#results: significant. p = 0.001
prop.test(x = c(study2f2f_accountability, study1f2f_accountability), n = c(study2f2f_N, study1f2f_N),
alternative = "less")

#Hypothesis study 2's online proportion is less than study 1's
#results: not sig. p = 0.15
prop.test(x = c(study2online_accountability, study1online_accountability), n = c(study2f2f_N,
study1f2f_N), alternative = "less")
```

```
## Interaction problems
#Hypothesis study 2's f2f proportion is less than study 1's
#results: significant. p = 0.01
prop.test(x = c(study2f2f_interaction, study1f2f_interaction), n = c(study2f2f_N, study1f2f_N),
alternative = "less")

#Hypothesis study 2's online proportion is less than study 1's
#results: not sig. p = 0.71
prop.test(x = c(study2online_interaction, study1online_interaction), n = c(study2f2f_N, study1f2f_N),
alternative = "less")
```