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INFORMATION SYSTEMS EDUCATION JOURNAL

Using a Concept Map to Represent the Composition of Knowledge in an Introductory Programming Course

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Abstract

Concept mapping, a tool originally developed to facilitate student learning by organizing and visualizing key concepts and their relationships, can also be used to represent the composition of the knowledge contained in a course. In this paper, the authors describe a specific application of concept mapping to help instructors and students visualize the knowledge contained in an introductory programming course of an undergraduate Computer Information Systems program. The authors show how representing the knowledge structure of a course using a concept map can enable the faculty to assess the breadth and depth of the knowledge imparted through the course. The authors discuss how a concept map that depicts the composition of a course can function as a useful instructional tool to assess and improve the quality of instruction that may enable meaningful learning among students.
Keywords: Concept-Map, Knowledge-Representation, Knowledge-Model, Programming, Course, Nodes, Links

1. INTRODUCTION

Any person who wishes to reason about his/her world comes across an inescapable fact that reasoning is a process that goes on in the mind of the person, while the very thing she/he wishes to reason exists outside the mind. This unavoidable dichotomy is the fundamental reason as to why we need some form of representation, or model, of the world about which we need to reason. This representation exists as a substitute for the real thing about which we wish to reason. Any operation that we wish to perform on the real thing can be performed on the representation and reasoning itself will be the surrogate for the action that we want to perform on the real thing.

In this paper, our focus is on creating a representation model for the knowledge contained in an introductory programming course and to use this representation to reason and draw inferences about various structural attributes of the knowledge contained in a course.

In order to be able to use a knowledge model, one needs to clearly know the intended purpose of this model, and the attributes of the real world that this model incorporates. In this paper, the proposed knowledge representation model intends to model the knowledge contained in the course as a network of concepts that the learner should master to result in a meaningful learning experience.

By selecting a knowledge representation model - which models a course as a network of concepts, we make an 'ontological commitment' that brings to focus a certain aspect of the course and blurs several other facets of the course. For example, the knowledge model does not model all the course contents explicitly, nor does it model the time required to learn concepts, all of which are important facets in the design of a course and will depend on the specific teaching context. The proposed knowledge representation model purely focuses on the skeletal structure of the knowledge base of the course.

Different forms of knowledge representations, known as 'ontologies', have been extensively used to model domain knowledge for teaching and learning purposes, primarily in the area of Personalized Learning Systems (Brusilovsky et al., 2004(a); Brusilovsky et al., 2004(b); Lee & Segev, 2012). According to one of the definitions "an ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base" (Swartout et al., 1997). Unlike a taxonomy that classifies and organizes knowledge components, an ontology specifies the knowledge components and their relationships in greater detail.

Ontologies have been used to provide common vocabulary for query retrieval in a case-based recommendation strategy for personalized access to learning objects (LOs) in a learning system (Gomez & Diaz, 2009; Brusilovsky et al., 2004(a); Brusilovsky et al., 2004(b); Lee & Segev, 2012; Wang & Mendori, 2012). In such learning systems, we observe a knowledge model that depicts a tree-like organization of the concepts and/or learning objects. For example, Appendix A, shows a hierarchical tree-like structure used to create an ontology for the C Programming language (Sosonovsky & Gavrilova, 2006). A five-step algorithm has been proposed by Gavrilova et. al, to develop teaching Ontologies (Gavrilova et al., 2005). This algorithm has also been used to develop teaching Ontologies for the Java programming language (Ganapati et al., 2011). In all these examples, the Ontology categorizes the units of knowledge in the form of a tree-like hierarchy. However, our goal of creating the knowledge model is to organize and inter-relate the concepts, in way that will make it possible for students to learn how to write computer programs. Such a knowledge model may contain cross-links between the concepts and may result in a non-hierarchical structure.
In the proposed knowledge model, we depict such cross-links, and in this way, create a generalized network-like structure of organizing concepts. To organize and represent the key concepts of a course in a network-like manner, we propose to use a concept map based approach.

The design methodology of concept maps was first introduced by Joseph Novak by re-examining Ausubel's learning theory that differentiates rote learning from meaningful learning (Ausubel, 1963; Ausubel, 1968). The fundamental idea in Ausubel's cognitive psychology is that meaningful learning occurs by the assimilation of new concepts and propositions into the existing conceptual frameworks held by the learner (Ausubel, et.al, 1978). Novak argues that knowledge construction is nothing other than a relatively high level of meaningful learning, and that concepts and propositions are the building blocks for knowledge in any domain (Novak & Gowin, 1984; Novak, 2002). Novak compares concepts to atoms, and propositions to molecules. Just as molecules are formed by atoms and the valid relationships that bond them, propositions are formed by valid relationships among concepts. For example, consider the two concepts car and engine. The proposition can be an assertive statement such as, car has engine (see Figure 1). Here the linking word 'has' relates the two concepts, car and engine (Novak & Canas, 2008).

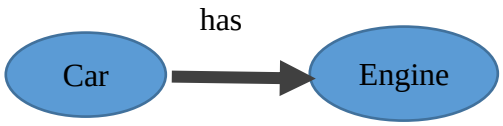

Figure 1. Example of depicting a proposition using nodes and link

Concept maps have been used as a scaffold for cognitive processing of knowledge in a given subject area (O'Donnell, et.al, 2002). Concept maps have found a wide variety of applications in the development of curriculum and instruction (Allen et al., 1993; Edmondson, 1993). Concept maps may be linked to high level learning objectives to create a 'finer-grained' learner model in an introductory programming course (Kumar, 2006). Concept maps have been used to represent the domain model, and also as an overlay student model in the design of tutoring systems (Mabbott & Bull, 2004). Concept mapping exercises and their scoring methods have been developed for testing students'

knowledge in an introductory programming course (Keppens & Hays, 2008).

The scope of this paper does not address the use of a concept map as a way to measure the learner's ability to create a computer program. Neither does the paper address the ability of students to construct their own concept maps. In this paper, a concept map is an instructional tool that will help instructors to represent the knowledge required to write procedural style computer programs in an introductory programming course for an undergraduate Computer Information Systems (CIS) program.

The figure shown in Appendix B, depicts a complete concept map developed by the authors. We explain the key design features of this concept map that can help the course instructors and students to understand the inter-relatedness of key concepts covered by course. We introduce some of the course quality attributes that can be inferred from the concept map. We also provide a sample implementation of a concept map based instructional strategy in a programming course. Finally, we provide a critique on the utility of the proposed concept map as an instructional tool to analyze the composition of the course contents to improve the quality of the course.

2. CONCEPT MAP OF AN INTRODUCTRY PROGRAMMING COURSE

The figure shown in Appendix B depicts the concept map representation created by the authors, for an introductory procedural style, Java programming course of an undergraduate CIS program. The concepts (i.e., nodes depicted in the figure) are extracted from the syllabus prescribed by the university approved course curriculum. The links that represent the relationship between the concepts were created by the authors to show the relationships between the key concepts.

The figure shown in Appendix C, depicts a partial view of the course syllabus. It can be inferred from the syllabus that there is a great emphasis on using programming concepts to solve problems. Additionally, the syllabus focuses on using case studies to outline the pseudocode problems, for which students are expected to create a programming solution. To represent the relationship that exists between problem solving and program structure, the concept map is divided into two clusters – the concepts that are part of the Problem Structure, and the concepts that describe the Programming Structure. This high level division follows the common teaching practice of many programs, where students are first made to analyze the problem, write pseudocode, and only then, write the computer program.

2.1 Mapping the Course Composition

As previously mentioned, the intent of the knowledge representation scheme is to map the composition of the course's subject area as a network of concepts and their interrelatedness. The key concepts to be covered by the course are identified and represented as distinct nodes in the concept map. The next step is to connect these concepts using proper linking phrases that can meaningfully convey the relationship between concepts that the instructor must convey through course contents and the student must learn, to successfully meet the course objectives.

In the concept map shown in the figure in Appendix B , the links between the concepts are primarily labeled using the phrases – 'is a type of ', and 'has'. It is typical for course domain ontologies to focus on 'is-a-type' and 'has'/'part-of' relationships between concepts (Omez-Albarran & Jimenez-Diaz, 2009; Sosnovsky & Gavrilova, 2006) . However, it is to be noted that concepts maps have no restriction on what kind of meaningful phrases that can be used to label the links.

The relationships indicated in the concept map are read along the direction of the arrows. For example, the relationship between Program and Method(s) is read as, "A Program has (one or more) Method(s)". The relationships can be of the 'one to one' type, or of the 'one to many' type. In a 'one to many' relationship, the concept on the many side is written in plural tense such as Method(s), or Expression(s). The non-arrow side of the relationship is always singular, and the arrow side of the relationship can be singular or plural. If the arrow side of the relationship is a plural, then the concept at the arrow side will be indicated in plural tense.

The selection of meaningful phrases used to label the relationships depends on the intent of the concept map. Since the primary goal of the concept map is to represent the course composition, the words 'has' and 'is a type of' convey the composition, and choices of composition, respectively.

For example, the concept map fragment in Figure 2, shows how programs are composed of some of the concepts. In this concept map

fragment, a "program *has* (one or more) method(s). A method is *of type* main method. A method *has* (one or more) statement(s), and a statement *has/is of type* expression(s)." This chain of reasoning indicates a program is *composed* of one or more methods, and a method is, in-turn, *composed* of one or more statement(s), and a statement is *composed* of one or more expression(s). The 'has' relationship indicates that one concept is composed of another concept. There are two types of relationships between statement(s) and expression(s). A statement is always composed of an expression and some statements only have expressions (i.e., no loops, or branches, for example).

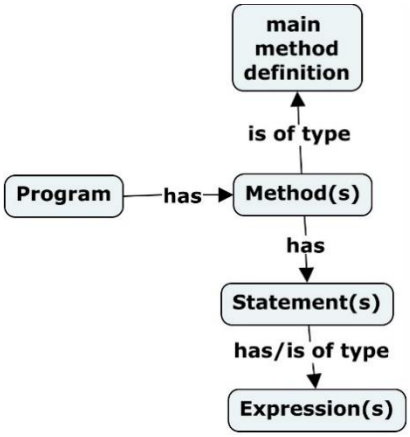

Figure 2. A small subset of the course concept map showing program composition

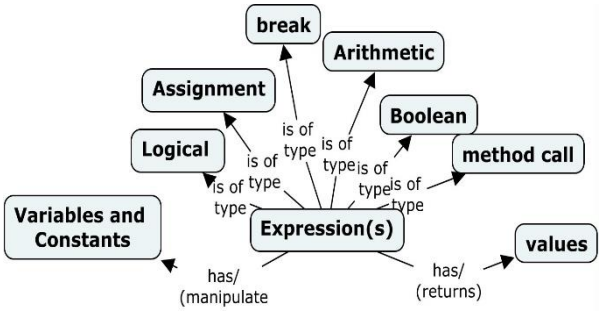

Figure 3. A Small subset of the course concept map showing 'is a type of' inheritance relationship

The 'is of type' linking phrase indicates 'choices of composition' that the learner must be able to discern for a given problem. This kind of a relationship indicates the need for the learner to discern among several permissible options of program or problem composition. For example, the concept map fragment in Figure 3, shows that every Statement *has* Expression(s), and an Expression can be *of many types* (such as Assignment, Arithmetic, Logical, Method call, Boolean, and Break). From this one can infer that to compose a statement, one will need to discern among, and choose from, a set of permissible expressions.

2.2 Mapping concept hierarchy

Even though a concept map has an overall network-like structure, sections of the concept map can define several types of tree-like, hierarchical relationships between concepts. Appropriate linking phrases can be used to depict these hierarchical relationships. One such hierarchical relationship, that we observe in the concept map depicted in Figure 1, is that of the concept of inheritance between what can be called the 'child' and 'parent'. The linking phrase, 'is a type of' relates a 'child' concept, to a 'parent' concept, as shown in Figure 4. For example, the concepts named Selection and Iteration are the child concepts of the parent concept called Statement(s). A single parent may have one or more child concepts and a child concept may, in turn, be a parent to its own child concept(s). For example, in addition to being a child concept of Statement(s), the Selection concept is a parent of the concepts named if..else and Switch.

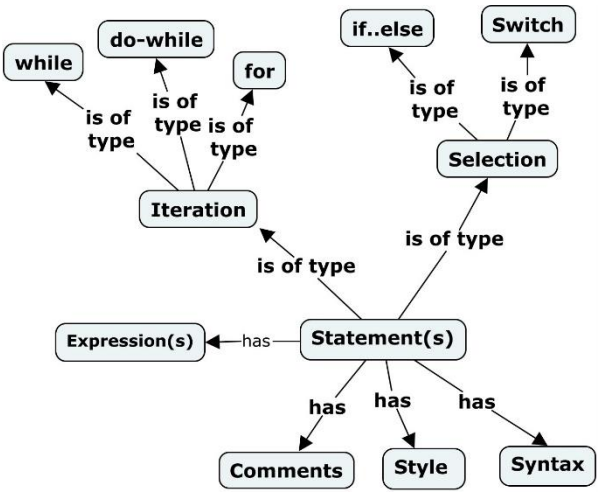

Figure 4: A small fragment of the course concept map showing concept hierarchy and inheritance

The 'is a type of' relationship indicates 'inheritance' of pre-requisite topics from the parent node. For example, in Figure 4, the concept called Statement(s) is composed of several concepts such as Expression(s), Style, Syntax, and Comments. All these pre-requisite concepts are inherited by the child nodes –

Selection and Iteration. This implies both Selection and Iteration lessons require the lesson on Expressions to be covered a-priori.

It can be inferred that the parent concepts are relatively more abstract, as compared to a child concept. This means the child concept provides more concrete course contents and learning implementation of the parent concept. For example, in Figure 3, the Parent concept called Expression(s) are learnt in concrete forms as Assignment expressions, Arithmetic expressions, etc.

2.3 Inferring the Pre-Requisite Concepts

Each node in the concept map can be considered as one lesson/topic of the course. For example, a typical programming course has a topic called Selection that will introduce the ways to write 'if..else' decision structures in the program. Another example of a commonly taught topic is that of writing various types of Expressions, such as an expression for variable assignment, an expression for arithmetic computation, etc.

Even though each lesson can be depicted as a separate node in the concept map, these concepts may require that the learner has mastered one or more pre-requisite concepts. For example, let us take the two concepts – Selection and Expressions, as shown in Figure 4. The two concepts are related to each other indirectly, through the Statement(s) node. The Statement(s) node is related to the Expression(s) node through a 'has' relationship. For example, to write an 'if..else' statement, one needs to know how to write a Boolean statement, that returns a value of true. This return value of the Boolean expression will then be used to trigger the code under the 'if' block. An 'if..else' statement block also may contain various arithmetic operations, or method calls. Thus, the inference that an 'if ..else' statement is composed of expressions, implies that the lesson on expressions should precede the lesson on Selection.

From the concept map shown in Appendix B, one can infer the order, in which lessons need to be taught, starting with the concepts that require fewer pre-requisites. For example, the lessons are typically taught in the following order: Data Units—Variables and Constants (along with primitive data types), Declaring variables, Expressions, Writing statements that have declaration and expressions, Selection structures, Iteration structures, and Methods.

3. INFERRING THE QUALITY OF KNOWLEDGE IMPARTED BY THE COURSE

The focus of the concept map presented in this paper is to reason about the composition of the introductory programming course designed to teach programming to beginners. Therefore, we will discuss how the structure of this composition impacts the quality of the course.

3.1 The breadth of the course

The breadth, or the scope of the course can be loosely defined as the number of topics covered in a course, which is typically defined in the course syllabus. The breadth of the course, as depicted by a concept map, can be assessed by the total number of concept nodes present in the map. For the example, the concept map shown in Appendix B, has 43concepts.

As discussed in the previous section, having a web-like knowledge structure, does not prevent creation of hierarchy, or levels of abstraction. Some of the concepts, for example, the Arithmetic expression, can be further split into an expression with operators such as, addition, subtraction, division, multiplication, and modulus. Similarly, the concept called Primitive Data Types can be split into integer, double, character, String, Boolean, etc. In this case, the breadth of the concept map will account for all the child nodes that form the body of knowledge.

The breadth of the course only counts the number of concepts covered in the course, but it does not convey how the course imparts knowledge about the interconnectedness of these concepts. The breadth does not convey how densely, or sparsely interconnected these concepts are, in the body of knowledge taught in the course.

3.2 Depth of the course

Compared to the breadth of a course, denseness, or depth, has always been perceived as a qualitative measure that may depend on the conceptual details taught and assessed for each topic of the course. For example, a solution to a 'dense' problem may require students to meticulously reason and connect together concepts acquired from several previously taught topics in an accurate manner. This pre-requisite knowledge may include concepts that may be an integral part of the newly introduced concept. The pre-requisites may also include those concepts that that are alternatives to the new concept and that the students may need to discern correctly. A 'dense' problem packs and

interconnects several concepts into the solution. The ability of the learners to form a coherent chain of reasoning that ties several concepts and that allows the learner and pick and choose the correct concepts leads to deeper learning. A concept map explicitly depicts the links between various concepts. Therefore, a solution to a dense problem may require students to reason along a 'chain of links' that connect various concepts in the concept map.

Deeper learning occurs when students are able to associate one concept to several other concepts listed in the course. For example, a simple Hello World program that is usually the first program that a student may write, actually binds 14 different concepts using the links depicted in the concept map. Figure 5, depicts those concepts. While it is possible and even sometimes desirable for novice students to be able to write an initial Hello World program without reasoning through so many concepts, this kind of learning will only promote superficial and rote learning in the long run. Therefore, to promote deeper learning, and mastery of concepts, the learner should be provided with instruction and practice activities that will teach how to reason well by identifying the correct concepts and their interconnectedness that can explain the solutions to the problems.

Learning Path : 15 Concepts
Concept: Business Problem
Concept: Input/Output: **Outputs Hello World**
Concept: Functional requirements : To output ***Hello World***
Concept: Sequence of operations /pseudocode: ***To output/print two words***
Concept: Method Call: ***call the System Output method to print Hello World***
Concept: User/System Input/Output: ***System Output***
Concept: Program: ***Created as a Class HelloWorld***
Concept: Executable Class: ***HelloWorld.java***
Concept: main method: ***has statements***
Concept: Method(s) : ***only main method***
Concept: Statement(s): ***has an expression***
Concept: Expressions: ***has a method call***
Concept: method call: ***System.out.println("Hello World")***
Concept: Data : ***"Hello World" used in method call***
Concept: Literals/Value: ***"Hello World" is a String literal***

Figure 5: A chain of concepts involved in a simple "Hello World" program

Figure 6, shows the concepts and the chain of reasoning involved in a simple program involving arithmetic expressions. This program chains 26 concepts that form a small subset of the concept map.

It is theoretically possible to create a problem whose solution will involve the entire concept map and requires students to reason through all the concepts and links. Solutions to smaller problems may constitute a smaller subset of the concept map, comprised of fewer nodes and links.

Learning path : 24 concepts
Concept: Business Problem
Concept: Functional requirements : **Obtain two inputs, add them, output the res**
Concept: Input/Output: **Input two integers, output the result**
Concept: User/System Input/Output: ***both system, input and output***
Concept: Sequence of operations /pseudocode: ***Method call, add, assign, meth***
Concept: Arithmetic :***addition- perfom input1 + input2***
Concept: Assignment: ***assign output = input1+input2***
Concept: Method Call: ***To get input1 and input2, To print output***
Concept: Program: c***reates a class AddIntegers***
Concept: Executable Class: c***reate a file AddIntegers.java***
Concept: main method: ***in the program, has statements***
Concept: Method(s): ***only main method***
Concept: Statement(s): ***has expressions***
Concept: Expressions: ***method call , Arithmetic, Assignment, Declaration***
Concept: Arithmetic: ***addition operator to add input1+ input2***
Concept: Assignment:***to assign values of input1, input2 and output***
Concept: method call: ***nextInt(), System.out.println()***
Concept: Declaration: ***declare variables input1, input2 and output as int***
Concept: Syntax
Concept: Style
Concept: Comments
Concept: Variables and Constants: ***3 ints***
Concept: Primtive Data types: ***int***
Concept: Data units: ***values of input1,input2, output***

Figure 6: A chain of concepts involved in a simple problem that performs addition on two inputs and outputs the result

4.0 IMPLEMENTING A CONCEPT MAP BASED COURSE DESIGN

The concept map depicted in Appendix B was used to assess and re-design a 15-week course on Java Programming. Initial assessment of the course indicated the need to instruct in greater detail the teaching of reasoning that goes into composing a program. The course contents were re-designed after adopting the concept map as the course content schema. In this section we reflect upon the implementation experience.

4.1 Assessment of Course Quality

The 15-week course on Java Programming includes all the topics mentioned in the course syllabus.

1) Intro to Java, writing a simple program. Basic Input/Output. Identifying errors, writing good comments.
2) Intro to variables, identifiers, assignment operator, and arithmetic operations, using int and double variables

3) Using char and String data types, int-double type conversions, math methods, and random numbers
4) Variables
5) Branches. Use of if-else branches. Relational and equality operators, logical operators.
6) Switch statements, Boolean data types.
7) String comparison, access and modify operations, char and conditional expressions.
8) While loop
9) For loop, break
10) Intro to methods, parameters, and return statements.
11) Methods with branches, loops, method name overloading.

All the above-mentioned topics involved exercises that identify the programming constructs required to solve a problem.

The instructors have commonly observed that students tend to learn the code by rote, without being able to 'see' the common patterns or inter-relatedness between concepts that occur in the structure of the program. For example, while writing a loop, many students fail to understand that the looping condition is an expression that returns a Boolean value. While Boolean expressions were previously taught, students may not fully integrate the past lesson into the new concept. As a result, many try to learn the worked out program by rote, and thereby failing to apply what was learnt to new problem. Some of the topics that were perceived to be most difficult were the topics covered later in the course such as: branches/selection, loops/ iteration, and methods. All of these topics require mastery in applying a large number of pre-requisite concepts.

One of the main motivations for re-designing the course was to re-create contents that focus on the conceptual knowledge and reasoning required to compose a programming solution to a given problem. The re-design would create instructions to explicitly show the relationships between various concepts required to create programs.

4.2 Using the concept map to assess and re-design the quality of instruction

An initial assessment of the course syllabus showed that the course had the required breadth and covered all the required concepts mentioned in the course syllabus. Additional concepts were added to emphasize the role of pseudocode and various types of sequence of operations that students had to infer from the business problem before writing the program.

The course lectures and assignments were investigated topic-by-topic to determine whether they have contents that explicitly conveys the relationships between various concepts covered in each topic. Additional lecture slides and code demonstrations were created to depict the relationships between various concepts involved in the topic. The "has" and "is a type of" phrases were used to depict the relationships between concepts.

To promote meaningful learning among students the programming demos expressed a program in-terms of its conceptual composition. All the concepts involved in the problem statements and the programming solutions were explicitly explained during the demonstration. The initial re-design of instruction had not considerably changed the course sequence and the programming activities. The only change was in the instructional narrative that incorporated the concept map and the program composition methods that included the chaining of concepts, as explained in Section 3.2. The newly re-designed lectures used the concept map to bring greater clarity to the lectures and programming demonstrations. The programming activities required students to reason through their program using the chain of concepts, as shown in Figures 5 and 6. Students were made to complete worksheets such as the ones shown in Figures 5 and 6.

4.3 Evaluating the impact of instruction re-design

In order to evaluate the impact of re-designed instruction, the learning outcomes of the re-designed course were compared with the outcomes from the previous semester. A scoring matrix, as shown in Appendix D, was used in both semesters. For comparison purposes, scores from six similar assignments were used to compare the outcomes of the re-designed instruction.

Each student was scored on a scale from 0 to 5, with 0 being the lowest score, and 5 being the maximum score. The average scores, before and after the course design are depicted for each component of the score matrix shown in Appendix D. The x–axis of each of the charts below shows the assignment number, with assignment 1 requiring knowledge of fewer concepts, and assignment 6, requiring knowledge of more concepts. Figures 7, 8, and 9

show the score matrix items that showed an improvement in learning gains, after the instruction was re-designed. Scores were obtained before and after the instructional redesign, for 28, and 26 students, respectively. The average class scores were rounded up to the closest integer value.

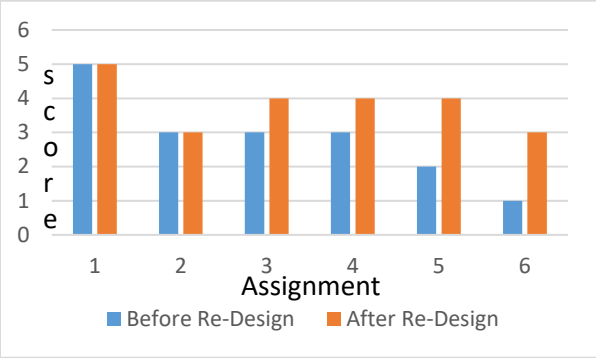

Figure 7: **Average scores of students in their ability to write the order of statements correctly, as required to meet the requirements of the problem.**

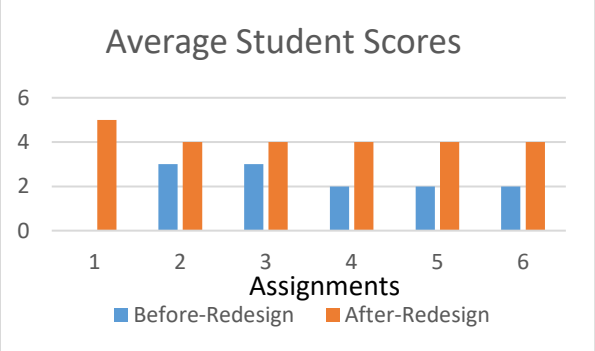

Figure 8: **Average scores of students in their ability to identify the correct type of statements required to solve the problem**

It can be observed from Figures 7 and 8 that the greatest learning gains, due to the re-design of instruction, were in the later assignments that were more 'dense' and packed several concepts into a reasoning chain. There were gains in the student's ability to identify and write statements in proper order. Gains were also observed in the ability of students to identify the proper type of expressions required to complete statements. However, students' ability to write correct expressions to complete the statements did not show marked improvement, as depicted in Figures 9 and 10. In most cases, the statements were incorrect because there were mistakes in the way the expressions were written. The majority of the mistakes were made in complex expressions that involved comparison and logical operators. Mistakes were also made in method calls.

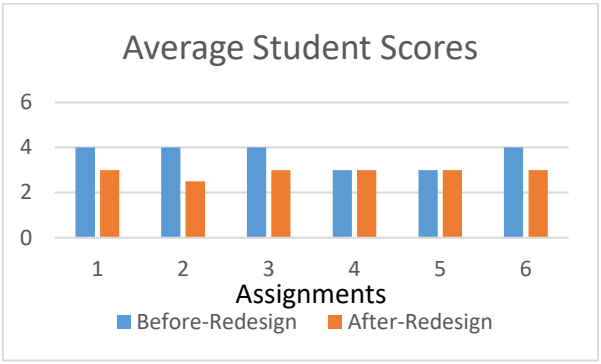

Figure 9: **Average scores of students in their ability to write all the expressions correctly**

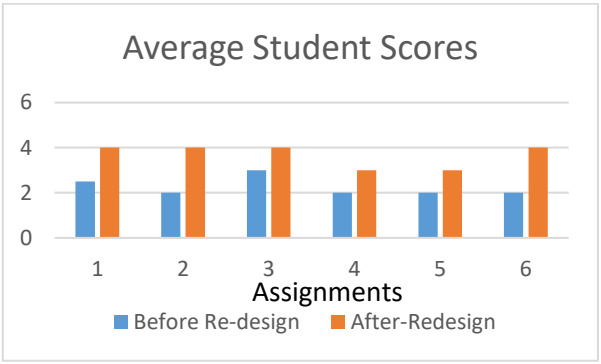

Figure 10: **Average scores of students in their ability to identify proper expressions for statements.**

Overall, the use of course knowledge representation using a concept map guided the instructor to create instructional material that combines conceptual knowledge with the practice of writing programs. The concept map provides students and the instructor a common vocabulary and representation to discuss the concepts. By chaining various inter-related concepts, the instructor was able to create instructional materials that makes explicit the systematic chains of reasoning required to compose programs. The effect of introducing a

new concept map based instruction was measured through assessment of weekly assignments provided to students. The results of the assessments provided the instructor with useful information about the concepts and chains of reasoning, for which improved instruction might be required.

5. CONCLUSIONS

This paper presents the possibility of using a concept map to represent the knowledge composition of a course that requires students to learn to write procedural style programs in Java. The intent of using a concept map was to map the knowledge composition of the course in the form of concepts and their interconnectedness, such that the depiction can be used to create instructional methods that can help students to learn how to compose programs. The structure of the concept map can inform the course designers about the breadth and depth of the knowledge imparted through the course. Using examples, the authors show how the interrelated-ness of concepts can be used to create chains of reasoning to explain programming solutions to different types of programming problems. Consequently, the concept map also helps students to learn meaningfully by enabling them to interconnect various concepts to produce programming solutions.

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Appendix A

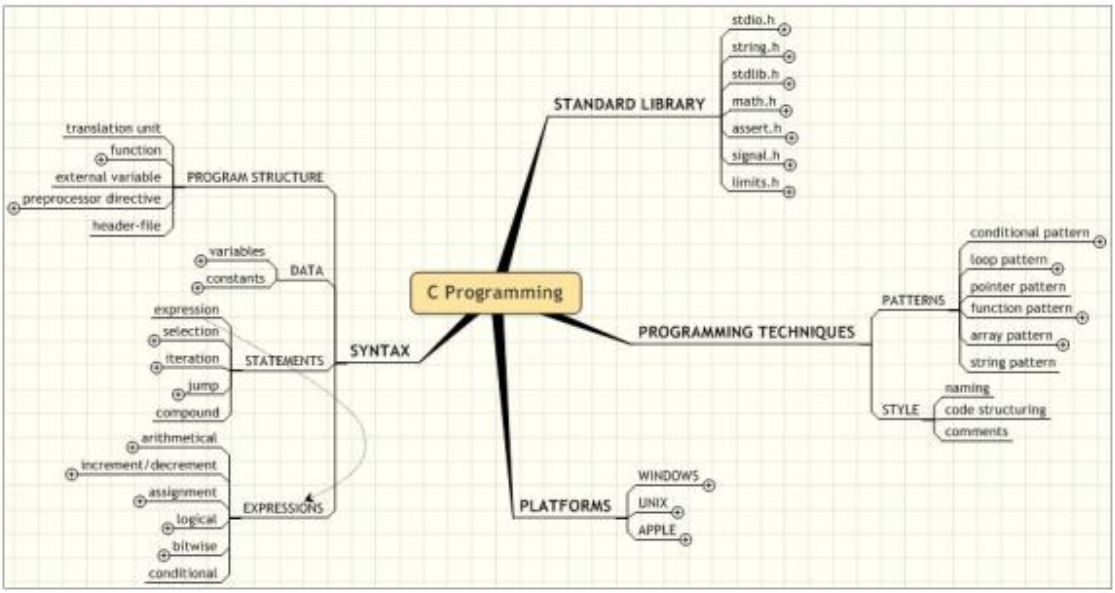

Figure A. Tree-like structure of an educational ontology for C-Programming (Sosonovsky & Gavrilova, 2006)

APPENDIX B

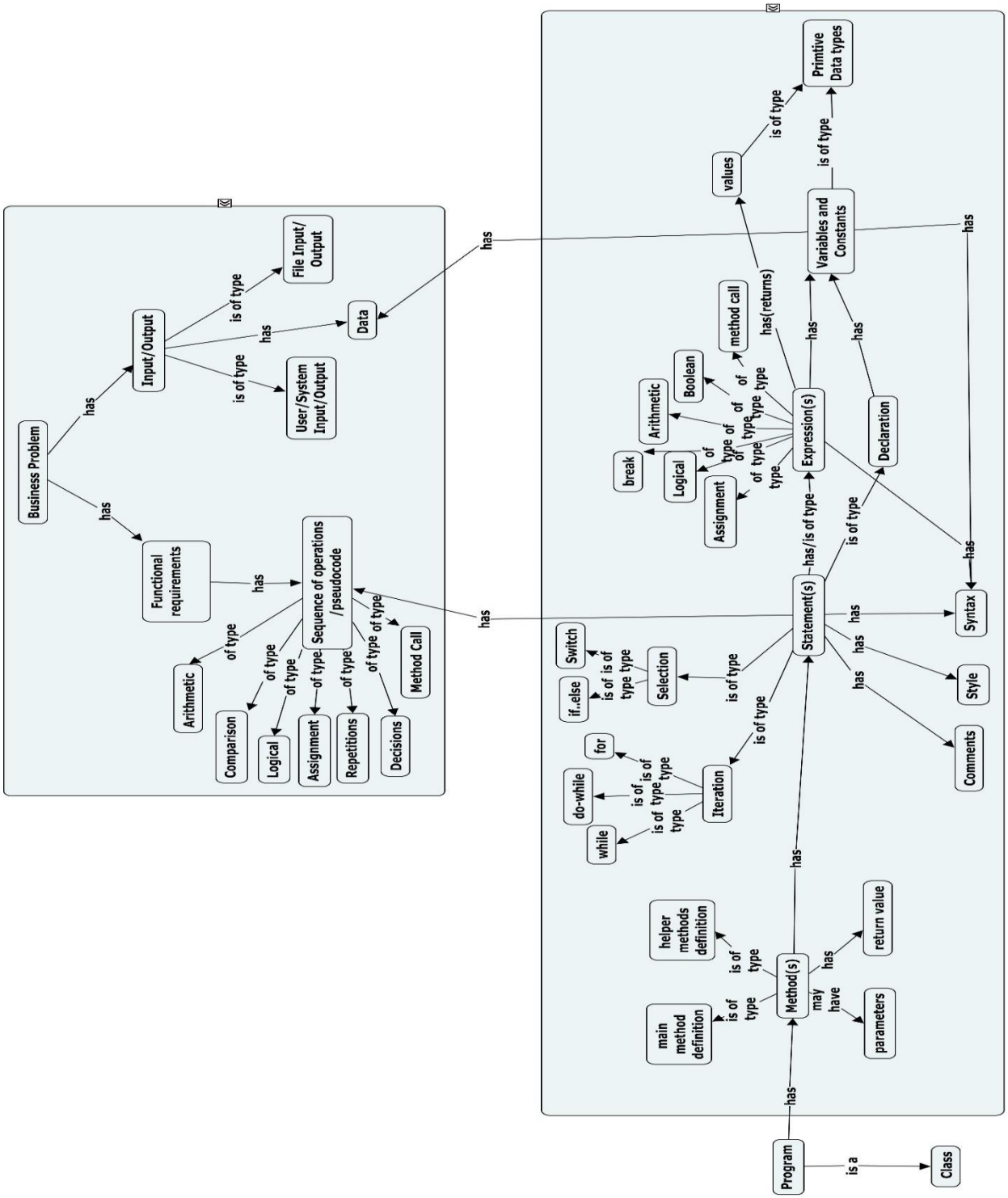

Figure B. Concept Map of an Introductory Java Programming Course

APPENDIX C

A. Objectives of the Course:

Upon completion of this course the student will be able to do the following items using the presently adopted language for this course (Fall 2010: Java):

a) Analyze business case studies and discuss strengths and weaknesses of various potential solutions.
b) Recognize and use problem solving techniques and methods of abstract logical thinking to develop and implement structured solutions of given software design problems.
c) Apply problem solving techniques and design solutions to business problems and implement these solutions by writing computer programs.
d) Write well-structured business programs.
e) Evaluate and debug programs.
f) Work in collaborative groups.

B. Catalog Description:

This course provides students with an understanding of business problems that are typically solved by writing computer programs, problem solving techniques to enable students to design solutions and programming skills learned in a traditional CS1 course. Emphasis is placed on efficient software development for business related problems. Students are required to write, test and run programs. Prerequisite: High School Algebra or Equivalent. Three credits.

C. Outline of the Course:

a) Problem Solving Techniques for Business Problems
   i) Business Case Studies
   ii) Problem Identification and Understanding
   iii) Solution Planning (flowcharts, pseudo-code, etc.)
   iv) Algorithm Development

b) Programming Concepts
   i) Structure of a Program (“Hello World”)
   ii) Constants, variables and data types
   iii) Arithmetic operators
   iv) Relational operators
   v) Logical operators
   vi) Assignment statements
   vii) Input and output
   viii) Selection (if/else and switch)
   ix) Repetition (while, do/while, and for)

c) Strings

d) File Processing

e) Functions (in presently adopted language, “method’’)

Figure C. A portion of the prescribed syllabus of the Introductory Programming course.

APPENDIX D

	Student is able to write the order of statements correctly, as required to meet the requirements of the problem	Student is able to identify the correct type of statements required to solve the problem	Student is able to identify the correct type of expressions to compose the statements	Student is able to write all the expressions correctly	Student is able to correctly identify the variables and its data types required to capture the data in the problem	Student is able to obtain the required inputs, as required by the problem	Student is able to correctly output data as per the problem requirements
Assignment 1:							
Assignment 2: Statements with expressions, input and output							
Assignment 3: Statements with variables,expressions, input and output							
Assignment 4: Statements with if.else / switch , variables, expressions, input and output							
Assignment 5: Statements with various types of loops,variables, expressions, inputs and outputs							
Assignment 6: Statements with if..else, loops, variables, expressions, inputs and outputs							

Figure D: A sample rubric used to evaluate the learning outcomes of each student in a programming course. This rubric is used to measure a student's ability to write correct programs that meet the requirements of a given business problem.

Designing and Implementing an Undergraduate Data Analytics Program for Non-Traditional Students

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Abstract

This paper discusses Implementation of a new educational approach to develop competencies for the future STEM workforce, and to build knowledge on success factors for educating a non-traditional target population in data competencies. It is widely accepted that a data capable workforce is critical to science and industry. The literature suggests that the need for data science and data analytics competencies in industry and academia is accelerating at a rapid pace. At the same time, census and demographic data predict that the pool of traditional college age students will continue to decrease. To meet the increasing demand for a data capable workforce, it is essential to leverage the non-traditional student pool, reskilling and upskilling the current workforce, simply because the traditional student output is nowhere near sufficient to meet the need. The current work is to implement a new program designed to provide adult learners with bachelor's degrees and post baccalaureate certificates in Data Analytics. This results in upskilling or reskilling the existing workforce to add value to industry and academia. The program is differentiated from traditional programs by catering to non-traditional students through specific pedagogies such as incorporating required mathematics competencies into Data Analytics courses, using specific pedagogies proven to work with the non-traditional population, as well as removing constraints by offering evening courses, easing registration obstacles, etc. The paper suggests a proposed curriculum, discusses the rationale behind each differentiated option, and explains how the program is being implemented.

Keywords: Data Analytics, Data Science, Workforce, Education, Non-Traditional, Student

1. INTRODUCTION

The Need

Data Analytics is emerging as a significant workforce need in the 21st century. One of the NSF's 10 Big Ideas is harnessing the Data Revolution (2018). This idea includes developing a 21st century data capable workforce (NSF, 2018; HDR@NSF, 2018). The literature suggests that the need for Data Science and Analytics (DSA) competencies in industry and academia is accelerating at a rapid pace. Many academic institutions have or are developing programs to meet this need. At the same time, however, census and demographic data predict that the pool of traditional college age students will continue to decrease. To meet the increasing demand for a data capable workforce, it is essential to leverage the non-traditional student pool, reskilling and upskilling the current workforce. The decreasing pool of traditional students is insufficient to meet current and future workforce needs in both data science and data analytics.

There are some troubling signs regarding the pool of traditional undergraduate students. The number of college age students grew from 1870, peaking in 2012 (Sklar, 2018). The number of 19-20 year olds in the US has plateaued, and the number of those under the age of 18 is diminishing. This is also the case locally. For example, enrollments in the state community college system have decreased by some 25%

from 2012 to the present. There are some enterprising efforts to create new pools of non-traditional students. Community colleges are starting pathways programs for high school students to gain workforce certificates, and 4-year colleges are recruiting the increasing number of high school students graduating with associate's degrees. Still, the fact remains that with a decreasing pool of traditional students and an increasing need for DSA in the workforce, traditional DSA students are insufficient to meet current and projected needs.

There is no question that there is an immediate requirement for data competent workers both nationally, regionally and locally. Nationally, Columbus (2018) notes that Glassdoor has listed Data Scientist as the #1 best job in America for the past three years. The Glassdoor report (2018) also lists Data Analyst in the top 50. In a Burning Glass Report, Markow et al. (2017) predict the number of data and analytics openings to increase by 364K from 2016 to 2018. Regionally, the Greater Washington Partnership coalition of industry and academia has developed a series of workforce digital credentials, including data analytics, to facilitate increasing the amount of STEM workers in the region to meet industry needs (it will be seen that this effort had a significant effect on the current project) Finally, locally, a June, 2018 report by the UPCEA Center for Research and Strategy identified data analytics as the most highly recommended new program for development by the School of Professional and Continuing Studies (SPCS), based on a variety of environmental and demographic factors. The solution is to develop data competencies in non-traditional students to build them into the technical workforce of the future.

There are many students within the non-traditional demographic who would be obvious candidates for a DSA career. An example is the quantitatively competent student who attended college for a year, and who then dropped out since they were not ready for college, lacking the maturity to succeed directly following high school. Now, 5 to 10 years later, they are ready to pick up where they left off. Another example is the person who, whether they completed a degree in a different field, or did not complete a degree, needs to upskill or reskill because they desire a career change or have hit a glass ceiling. There are also those who could not afford, or were not mature enough to complete a bachelor's degree. Some had to work for a living, and most will work fulltime as they complete their bachelor's degrees.

What is a Non-Traditional Student?

There is no universal definition of a non-traditional student. However, demographic information gives perspective to the typical SPCS student. Entry data indicates that the average student age is 37. Although the majority of students have traditionally been men, the number of women in the program is slowly increasing, with women accounting for 46% of enrollments in 2015, and over ~50% of students in 2017 and 2018. Experience levels and goals of women are similar to those of the male students.

Eighty-one percent of students are part-time. For technology students, both part-time and fulltime students are working on either Bachelor of Science in Professional Studies degrees with a major in Information Technology Management or Information Security, or a post-bachelor Certificate in Applied Studies in Information Systems or Information Security. Student experience varies, with some having associate's degrees or at least some community college work, and have immediately transferred to SPCS with a desire to complete their bachelor's degree. Others have been in the workforce for some time, and need a degree for promotion. Still others are trying to break into the information systems field, often with significant life experience and success in other fields.

The result is that there is wide variance in student understanding, experience and ability. All of the major core courses are classroom courses, although some are offered in hybrid format. There are currently no completely online information systems courses, although some non-major courses may be taken online. Most of the students live in the local metropolitan area, and most stay in the area after they graduate. Courses are generally capped at 15 students, allowing significant individual attention and interaction with instructors.

This demographically diverse student population presents numerous opportunities as well as challenges. Many of these are well known and well documented elsewhere, such as the benefits of experience and maturity, and the challenges of family and work obligations. Whereas the traditional students continue to mature and learn to think critically during their degree programs, it is expected that the continuing students in this program focus more on professional competencies, with the focus for instructors to help students grow professionally.

2. LITERATURE REVIEW

There is no question that there is a need to reskill and upskill the current workforce to meet the needs of industry and academia for a data capable workforce based on National Science Foundation forecasts and priorities (NSF, 2018; HDR@NSF, 2018). The question is how to leverage the current workforce to that end.

Undergraduate DSA Programs for Traditional Students

While there are an increasing number of schools offering bachelor's level DSA programs, there are few oriented towards non-traditional students. According to Dataversity (2018), based on a forecast need for DSA professionals, many programs were developed, most of them leading to a master's degree. They note that while most lead to graduate degrees or certifications, there are several that result in bachelor's degrees, including Denison, Auburn, Arizona State, University of California – Irving and Smith College. There are an increasing number, including many not mentioned by Dataversity, including Trinity, Washington & Jefferson, Luther, Valparaiso, Iowa, Arkansas Tech, Northern Kentucky, St. Mary's, Brigham Young, Michigan and the University of Evansville. What all of the aforementioned programs have in common, however, is that they are oriented towards traditional students.

Non-Traditional Students Retention Factors

The factors affecting student dropout decisions are different for non-traditional students than for traditional students. In developing an attrition model for students, Spady (1970) finds academic performance to be the dominant factor in student dropout decisions, with social integration also a major factor. Tinto (1975) notes that many previous works did not differentiate academic failure from voluntary withdrawal, but that predictors of both are related to social integration, or lack thereof. Pascarella (1980) stresses the importance of informal faculty contact with students, with the implication that such contact positively affects social integration. Bean (1985) agrees with the previous studies with regards to the dominance of socialization, ad further suggests that peer interaction has a greater effect than faculty-student interaction. In a 1985 study, Bean and Metzner find that while previous studies on student attrition consistently find that social integration is a dominant factor in dropout decisions, it is considerably less important among non-traditional students. This is attributed to social and environmental variables outside the academic environment having a more significant role for non-traditional students.

Strategies and Pedagogies

Non-traditional students require different teaching and learning strategies. Knowles (1984) notes that adult learners are more self-directed and task oriented than traditional students. Because of these traits, Kenner and Weinerman (2011) suggest that instructors present material in ways that allow non-traditional students to see the purpose of the exercise. Failing that, instructors may face resistance to the learning strategy. Kenner and Weinerman further suggest that the material must be presented in a way that competes with previously learned learning strategies, so students understand the value of the new strategy. Further, they suggest that repetition be used, so that students can practice and discern the usefulness of the new strategies (2011).

Creative Programs

There are some programs that use interesting new approaches which may be applied to new programs. Denison approaches data analysis from a liberal arts standpoint, with a focus on critical thinking and problem solving. Participants are required to take interdisciplinary courses in a field of interest, which helps them assimilate applied problem solving. Valparaiso University has adopted a business analytics program that focuses less on technical aspects of data, and more on problem solving, visualization and communication. Ottawa University offers a fully online data science program designed for adult learners. Tenets of these programs may be added to the project program development.

3. DISCUSSION

This project develops and implements a data analytics undergraduate and certificate program to upskill or reskill non-traditional students in data competencies. The goal of this project is to facilitate and improve success of non-traditional students seeking to develop data competencies. This is accomplished by developing and implementing a program dedicated to the non-traditional student population, leveraging their strengths, while mitigating their weaknesses.

SPCS is Mostly a Degree Completion Program

Although it is possible to complete a bachelor's degree solely at SPCS, most students bring from

45 – 60 hours from other institutions. Many come from the two local community colleges. Others bring in transfer credits from previous work. The bottom line is that students may transfer up to 60 credits into their programs. The challenge is to develop a program that develops student data competencies within the last 60 credit hours of their undergraduate tenure.

Additional Non-Traditional Student Issues

As most of the students are working, many fulltime, class meetings are constrained by their availability. Courses are anticipated to meet once a week, on Monday through Thursday nights, and on Saturdays. This schedule in itself requires adjustment and consideration to pedagogical delivery. If students have children involved in sports, their Saturdays may be compromised. The limited number of periods when courses may be offered affects scheduling. Prerequisites for courses must be minimized to ensure that students are able to have course options to complete their programs. Consideration must be given to students taking their required math courses, and math competencies are required for many of the DSA courses. Required math courses for all SPCS professional bachelor's degrees are Finite Math and Applied Statistics. One issue is how to provide DSA students with the additional math competencies required for the DSA discipline.

Necessary Math

Many community college graduates with associate's degrees have completed Introduction to Mathematics, which introduces number systems, logic, basic algebra, and descriptive statistics. This course is not accepted for transfer to any 4-year institution in the state. Others take the minimum transfer math course, Quantitative Reasoning, which introduces proportional reasoning, modeling, financial literacy and validity studies (logic and set theory) in a very much applied fashion. Finally, there are those who transfer in with Pre-Calculus and/or Calculus. While it is presumed that the latter would be the best candidates for a DSA program, the reality is that there is wide variance in the students typically transferring or entering SPCS programs. The question is what math is required for a DSA program for non-traditional students? Data Science Weekly (2013) suggests several competencies for the DS resume, including linear algebra, regression, probability theory, numerical analysis and core machine learning methods.

It is suggested that new approaches in curriculum and pedagogy are required to service the non-traditional demographic and ensure the success of these students. This is a new audience – students who may not have received a recent, college preparatory and heavily quantitative high school education, but who have the maturity and capability of working with data. The reality is that to require typical DSA prerequisites of linear algebra, calculus, statistics and

Rather than forcing SPCS DSA students to undergo traditional quantitative courses to fill holes in their education, it involves integrating quantitative competencies into Data Analytics courses. It involves modifying pedagogies to place less stress on developing models, and more on using emerging and increasingly complex tools and cloud competencies to analyze, interpret and leverage the results. Critical thinking, problem solving and articulation of results are stressed. The challenge is to address the unique barriers to success for these students, ensuring their success in a data driven world. The specific math components covered in each course is driven by course content, and is anticipated to be developed as the courses are designed.

Sharp Sight Labs (2016) suggests that the amount of math necessary for entry level positions in industry (machine learning in this case) is not as much as one might expect. They posit that if one is educated in academia, there is a significant amount of math required, since academics research and develop the tools used by industry. As workers in industry, Sharp Sight Labs suggests that entry-level personnel spend more time using the tools to add value to the enterprise. This raises the question of the balance between modeling and algorithms, and using automated tools.

Labs and Tools

Many experienced practitioners cast aspersions on a perceived increasing proclivity of analysts to use automated tools and pre-configured dashboards. In information systems, the same has been said about automated database development tools and commercial-off-the-shelf-software for decades. However, as technology emerges, there is value in automating some repetitive functions, as well as some complex ones made easier using tools. That is not to say that students do not have to understand the algorithms and concepts used to develop models.

Wilder and Qzgur (2015) propose a business analytics program designed for non-technical business students. Manyika (2011) suggests that the US alone may face a shortage of between 140K to 190K positions requiring deep analytical skills, and 1.5 million managers and analysts who can analyze big data to make decisions. Although the article is somewhat dated, what is significant is the distinction between hard data scientists, and managers and analysts who can use the tools to add value to the enterprise by making decisions. Similarly, Markow et al. (2017) state that positions for data scientists and other advanced analytics competencies will reach 61,799. However, that number is only 2% of positions requiring data and analytics competencies. Wilder and Ozgur describe a program where data competent managers use problem solving, visualization and communications skills to add value.

In this project, it is not proposed that a technically light program be developed to focus on business skills. It is instead proposed that the program focus on ensuring students have sufficient math integrated into their courses for them to internalize concepts. Then, instead of modeling analyses, they use advanced tools to then understand patterns and solve problems, visualize and communicate their findings. The program development portion of this project includes building cloud labs to include emerging technologies and tools to keep students on the cutting edge of analysis techniques.

4. PROGRAM DEVELOPMENT

To summarize the discussion, the work of the new DSA program development must consider the following:

- It is anticipated that the need for DSA workers will increase, requiring additional entrants
- The traditional undergraduate pool is decreasing, requiring additional new populations
- Developing programs for non-traditional students will help meet demand
- Most undergraduate DSA programs are designed for traditional students, requiring tailored programs for non-traditional students
- Retention factors are different for non-traditional students, requiring different strategies
- Adult learners require different pedagogical approaches, requiring tailored programs
- There are some creative programs which should be examined and best practices noted
- SPCS is a degree completion program, with ~60 credit hours to cover all topics, making efficiency a major goal
- There is a lot of variance in student math preparation, which must be addressed
- Required math competencies are integrated into data courses, to be further addressed as courses are developed
- Entry level analytics positions focus on tools rather than modeling, so the program focuses on tools and visualization
- Courses develop use of tools, problem solving, visualization, communications
- Data science reflects only a small percentage of data and analytics positions
- Emerging technologies enable advanced analytics tools, so additional focus on tools is warranted
- Cloud labs are developed to facilitate the latest tools, easing lab requirements and improving capabilities
- A program for non-traditional students is developed and implemented and a model curriculum is developed
- A research project will report on program success, process and lessons learned

The goal of program development is to develop, implement and staff a program designed for non-traditional undergraduate and post-bachelor's career transitioning students seeking to develop data competencies. This involves developing an innovative DSA program to meet the unique needs of non-traditional students.

This work consists of developing a program or both bachelor's programs and Certificates of Applied Studies in Data Analytics. This involves developing a curriculum optimized to facilitate the success of the target population, meeting the requirements of accreditation and program operationalization in conjunction with the university Office of Institutional Effectiveness. Other analytics curricula are examined, and a program is developed with an emphasis on ensuring basic concepts are understood with required math integrated into courses, then focusing on framing problems, selecting analysis methods and tools, conducting and interpreting the analysis, and presenting the analysis so decisions can be made.

Once the development is complete, the new program must be approved internally by school faculty, Academic Council, Board of Trustees, etc. It is then sent for approval by the Southern

Association of Colleges and Schools Commission on Colleges (SACSOC) is the regional body for the accreditation of degree-granting higher education institutions in the Southern states. Once SACSOC and tuition assistance approval are granted, the program can begin accepting students. It is hoped that this will occur in the fall of 2020.

Quantitative and other requisite competencies will be integrated into such new courses as Data Management, Prescriptive Analytics, Descriptive Analytics, Predictive Analytics and Data Visualization. As most of the students are working, many fulltime, class meetings are constrained by their availability. Courses are anticipated to meet once a week, on Monday through Thursday nights, and on Saturdays. This schedule in itself requires specific pedagogies and methods to facilitate learning specifically targeted to adult learners.

By offering students a new major, Data Analytics, in the Bachelor of Science in Professional Studies (BSPS) program, and a post-baccalaureate Certificate of Applied Studies (CAS), SPCS believes it can further expand its program offerings to prepare students for data analytics positions in private industry and government organizations. Admission requirements for this new major will be the same as SPCS' current BSPS. The BSPS in Data Analytics focuses on what is needed for a specialized major in Data Analytics in addition to the existing structure of other majors. The Data Analytics major shares courses with the BSPS in IT Management and other BSPS majors.

In addition to the BSPS bachelor's degree requirements, the major in Data Analytics requires successful completion of 30 semester hours of undergraduate coursework in the major: 21 semester hours from the six required courses and 9 semester hours from the Professional Core courses. These Professional Core Courses (9 credits) for the BSPS in Data Analytics are the same as the BSPS in IT Management – Applied Ethics (3 credits); Leadership in the Global Environment (3); and Applied Statistics (3).

SPCS has established an initial enrollment target for the BSPS in Data Analytics major of 15-25 new students per year. Estimated potential student interest at the post-baccalaureate certificate level is an additional 10-20 new students per year beyond the number of students in the bachelor's program. Again, the program is expected to start in the fall of 2020.

The CAS in Information Security program requires a minimum of a bachelor's degree with a 2.0 cumulative grade point average (GPA) or higher. This is the same admission requirement as the current CAS program in Information Systems. Admission to the bachelor's degree also requires a 2.0 cumulative GPA on all college work. This is less selective than most DSA programs, again making the program structure important to student success. Adding more difficult quantitative requirements to the program sets students in a less-selective program up for failure.

Curriculum

The Data Analytics degree structure is based on the current BSPS degrees in Information Technology Management and IT Security. Requirements for the BSPS Major (21 credits*) and CAS in Data Analytics (18 credits) include the following:

- DSDA 3XXU Descriptive Analytics
- DSDA 3XXU Predictive Analytics
- DSDA 3XXU Prescriptive Analytics
- DSDA 3XXU Data Visualization
- DSDA 3XXU Data Analytics Elective
- DSDA 4XXU Data Analytics Capstone

All of the courses above are developed specifically for the program to include pedagogies specific to non-traditional students. These initial courses are loosely based on the business analytics curriculum described by Wilder and Ozgur (2015). Descriptions and justifications are as follows:

DSDA 3XXU Descriptive Analytics – the goal of this course is to introduce students to effectively describing events that have already transpired. Applied Statistics, is a prerequisite for this course. Applied Statistics gives the student a foundation in descriptive statistics, and this course strengthens that foundation and focuses on use of software, interpretation, problem solving and communication of results. This course takes Applied Statistics to the next step, and ensures that students have a strong foundation in basic statistical technique.

DSDA3XXU Predictive Analytics – the goal of this course is to which introduce students to determining future outcomes and trends from existing data to help predict new relationships. Students evaluate potential outcomes based on historical data predictors. Students use their problem solving skills, framing the problem, data sources, models and analysis methods. They then learn to apply predictive analysis methods,

use analysis tools popular in industry. The course prepares students to complete a cycle of framing a problem, identifying data sources analyzing, interpreting and articulating the results. Descriptive Analytics is a prerequisite for this course. Being able to derive future outcomes from existing data is essential to a career as a data analyst.

DSDA 3XXU Prescriptive Analytics – this course presents a comprehensive overview of the theory and practice of how to apply Prescriptive Analytics and optimization. The workflow for Prescriptive Analytics is discussed, from understanding the problem through selecting the approach and data, constructing simple models, and completing the analysis and interpreting and communicating the results. Descriptive Analytics is a prerequisite for this course.

DSDA 3XXU Data Visualization – this course teaches students various diverse techniques for presenting data to a targeted audience. Various tools and emerging technologies are used to visually present data to the best effect. Emphasis is placed on clear, simple communication. The goal is to give students the competence to explain complex concepts in simple terms.

DSDA 3XXU Data Analytics Capstone – the goal of this course is to ensure that students are able to manage and complete a real world analytics project. Project management and consulting basics are covered, as are client interaction and use of real world data. Students must frame the problem and choose and execute an appropriate analytics methodology. This should be the last course in a student's program. This is seen as an important part of the student's program. SPCS prides itself on the relevance of their students in the workforce. Having an applied practicum strongly supports this goal.

DSDA 3XXU Big Data Fundamentals The student learns that big data is not simply business as usual and the decision to adopt big data must take into account many enterprise and technology considerations. During the course, students examine current approaches to enterprise data warehousing and business intelligence. In addition, they explore key concepts related to the storage of big data datasets and how big data datasets are processed by leveraging distributed and parallel processing capabilities that have converged in the big data space. They also study the implementation of different flavors of NOSQL technology. Using the understanding of the big data paradigm students learn a range of big data analysis techniques. This course would ideally be a required major course, but there is not room under the existing curriculum structure, so it is offered as an elective in the proposed program.

Electives in data analytics will be offered throughout the program. A course in data mining will be offered, where students are taught to recognize opportunities for data mining approaches and exploit the results. A machine learning course will provide an introduction to basic machine learning methods, covering theoretical foundations and essential algorithms for supervised and unsupervised learning.

Field specific courses may be offered in collaboration with other programs, resulting in courses such as human relations analytics and analytics for education. A course in data management will help students learn to manage data as an enterprise asset.

The program is innovative in adopting practices, and culture designed to help non-traditional students succeed. These include:

- Specific learning strategies and pedagogical approaches
- Math competencies integrated
- Class schedule designed for working adults
- Assignments oriented towards non-traditional students
- Consideration for external social and environmental factors
- Focus on tools, interpretation and communication
- Use of cloud labs for improved access
- Use of emerging technologies, etc.

Program Implementation

Starting a new program is not for the faint hearted. Regardless of the amount of market analysis and due diligence on the part of the institution, there is always some degree of risk.

The initial implementation plan for the program managed risk by relying on a significant startup grant anticipated to be received from the National Science Foundation (NSF). However, this grant was not funded. The implementation strategy needed to be changed.

Earlier in this paper, it was mentioned that the Greater Washington Partnership/Business Higher Education Forum was developing a series of

workforce credentials requested by industry to provide standardized competencies to prospective job applicants. The university president, and SPCS, committed strongly to participate in development of the credentials, and to implement them throughout the university. The BHEF received a grant from the NSF to plan implementation of the credentialing program. Twelve participating institutions in the greater Washington metropolitan area were sub-grantees, of which SPCS was one. One of the credentials was for data analytics.

The first step in developing a plan involved determining which competencies were currently offered throughout the university. Courses from the School of Arts and Sciences, Business School, and SPCS were matched with the Knowledge, Skills and Abilities (KSA's) contained in the credentialing requirements.

In the case of SPCS, it was found that current courses MATH 265U: Applied Statistics, ISYS 311U: Database and Business Intelligence, and ISYS 315U: Big Data Analytics met many of the requirements for granting the data analytics credential. It was then determined the two additional new courses, ISYS XXXU: Data Visualization and ISYS XXXU Predictive Analytics should be added to cover all of the competencies. These courses are being added to the catalog to meet the credentialing requirements and as electives for information systems students.

Since the aforementioned courses are already in the catalog, the SACSOC proposal for a data analytics major only requires two additional courses be added to constitute the major. These include ISYS XXXU: Prescriptive Analytics and ISYS XXXU Data Ethics. It was decided to forgo the capstone course at present, and to add it later.

Implementing the program sequentially reduces risk, and simplifies the major during the approval process (internal approvals such as faculty, academic council, Board of Trustees, etc., and external approvals such as SACSOC and financial aid.

The result is a simple, easily implemented program that can be built upon to increase value in the future.

Labs

The requirements for labs for this program differ from that of traditional programs due to the presentation to non-traditional students as well as because of emerging technologies and paradigms. As previously mentioned, one of the key tenets of this program is for students to learn to use new tools that simplify data modeling and analysis. Non-traditional students, with their once-per-week class schedule combined with often busy work schedules, need non-traditional lab access. These tools are anticipated to be further defined as courses are developed.

At the same time, paradigms are changing around institutional support of information technology courses. The infrastructure costs of locally hosted applications are increasing to the point where a paradigm shift to cloud based applications is inevitable (Mew, 2015).

An example of this are two relevant courses currently offered by SPCS. The first is relational database and business intelligence course using an Oracle database. The database uses a university license on a locally hosted server. The university has traditionally supported this course with the enterprise license, but there is no guarantee what would happen if the server fails or the enterprise license is allowed to expire. The second example is a new course on big data analysis. The course requires students to use the industry standard MongoDB cross-platform document-oriented database program. With the university information services unable to host the program locally, MongoDB was hosted on an Amazon Elastic Compute Cloud (Amazon EC2) instance on Amazon Web Services. The advantages of using cloud-based applications are numerous.

5. SUMMARY

This program is anticipated to be a new paradigm for others desiring to implement a Data Analytics program for adult learners. It focuses on a simple implementation that focuses on problem definition, tools, analysis, interpretation and presentation. These are competencies that undergraduate entry-level students entering the workforce will find relevant. Finally, the project adds to the body of knowledge on developing data analytics programs for non-traditional students. Upskilling and reskilling non-traditional students currently in the workforce is essential to meeting the need for a data capable workforce of the future, and adds great value to the lives of participating students.

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Using an Electronic Resume Analyzer Portal (e-RAP) to Improve College Graduates Employability

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Abstract

Finding the first full-time, major-related job is a challenge faced by most college students, particularly those who have not gained much working experience before entering the job market. This challenge is amplified for the students majoring in Information Technology (IT), and cybersecurity in particular, due to the constantly changing technology landscape, intensively competitive markets, and increasingly high expectations from employers on their recruits. While the job demand is high in these fields, it is still difficult for recent college graduates to enter the field. This study shows the initial results of a tool called e-RAP which allows the students to submit their current resumes, obtain automatic feedback and a rating report, and consequently take actions to strengthen their portfolio. The authors employ machine learning and natural language processing (NLP) to create a resume analysis and reporting tool. The methodology section provides an overview of the e-RAP analysis process, followed by elaborations on data curation, data collection, and analysis techniques. Several visual examples of the reports generated by e-RAP illustrate the value of the tool in helping enhance students' resumes and eventually the skills areas they need to work on or highlight. A sample of more than 60 resumes were processed through e-RAP and the results were evaluated for potential resume improvements. The future direction includes systematic evaluation of the effectiveness of e-RAP and its impact on our student's ability to get high-quality positions. Diving deeper into the various types of cybersecurity positions is also planned.

Keywords: Resume Analysis, Natural Language Processing (NLP), Workforce Readiness, Technology Job Requirements, Major-Related Jobs, Machine Learning

1. INTRODUCTION

Getting that first job, even in a high-demand field such as cybersecurity, can be stressful for students. The 2018 McGraw-Hill Future Workforce Survey disclosed that only four in ten college students feel well-prepared for their careers (McGraw-Hill Education, 2018). According to the report, more than fifty percent of the students surveyed felt that they had not gained the substantial critical skills needed to transition to the workforce. For example, 57% of the students reported feeling a lack of problem-solving skills and 69% a lack of job searching

skills. This situation is amplified for the students majoring in Information Technology (IT), and cybersecurity in particular, due to the constantly changing technology landscape, intensively competitive markets, and increasingly high expectations from employers on their recruits: a broad range of specific technical skills, business domain expertise, and highly-refined soft skills. One of the recent cybersecurity workforce study shows that the global shortage of cybersecurity professionals reaches a worrisome number at 2.93 million ((ISC)², 2018, October 17). Sixty-three percent of organizations surveyed reported that their organizations have a shortage of dedicated cybersecurity workers and 36% of respondents rank the skills gap as their top job concern. The latest data further indicates that global cybersecurity workforce needs to grow by 145% to meet the demand for skilled cybersecurity talent and the U.S. market specifically requires an increase of 62% to better defend their organizations ((ISC)^2, 2019, November 7).

To close the skills gap, different stakeholders including business leaders, government agencies, and policymakers have proposed and experimented with a variety of workforce readiness initiatives and programs. For instance, some companies have developed their own talent pipeline program as the remedy (U.S. Chamber of Commerce Foundation: Center for Education and Workforce, 2014). Another example is the Department of Labor's Registered Apprenticeship Program(https://www.doleta.gov/OA/apprenticeship.cfm), which aims to connect individuals with careers from an early age. Labor-market intermediaries such as employment agencies, employer relationships with technical colleges or other institutions, and employer-provided training are some other initiatives proposed to bridge the gap between supply and demand (Weaver, 2017, August 25). However, most of those initiatives are not subject- or program-specific, require highly motivated personnel from all the involved parties, and have a lack of incentives and visibility. Therefore, those initiatives may not be scalable or sustainable in the long run.

On the other hand, higher education educators and administrators have been tackling these challenges from a different aspect, focusing on academic program renovation and resource realignment (College for Every Student (CFES), 2016; Forshaw et al., 2016). For instance, workforce readiness could be improved through more well-designed and well-planned internships, more guidance for career preparation, and better access to preparation tools (Hanover Research, 2016). Some universities have implemented connected curriculum or programs as a strategic framework to foster student research and internship opportunities as well as enrich the curriculum and student experiences (Fung, 2017). Another study uses a data-driven approach to reflect on the gaps and overlaps between the curriculum and skillsets in latest job postings (Green, Liu, & Murphy, 2019). To address the concern of the conspicuously low number of women professionals in the cybersecurity workforce (Frost & Sullivan, 2015, 2017), some educators have engaged in broadening the participation by females and preparing female students for the cybersecurity career (Liu & Murphy, 2016).

The authors have adapted multiple frameworks and best practices based on the above literature. According to the program outcome assessments, a series of job readiness activities embedded in the curriculum and extended over extracurricular have received generally positive feedback from the students. However, quite a few students, especially those who have limited working experiences in the IT and cybersecurity fields, expressed pressing needs to have faculty review their resumes and provide subject matter related suggestions.

Our prior study proposed an innovative as well as systematic approach- an Electronic Resume Analyzer Portal (e-RAP) to analyze students' resume, evaluate them based on job postings, and generate reports with ratings and suggestions on specific skill area(s) the students could or should work on. This tool is designed to complement the ongoing workforce readiness programs and initiatives in the authors' department and strengthen the students' portfolio and career readiness in the long run. We will provide a background introduction on the extant resume checking and enhancing tools in the market, followed by a brief overview of the unique approaches the e-RAP employs. An initial evaluation of the e-RAP was conducted by running analyses on 62 resumes gathered from our IT seniors. The results generated were examined and assessed for future improvement.

2. BACKGROUND

While there is a talent shortage in the IT field, particularly in cybersecurity, organizations receive many applications for each position advertised that come from a variety of sources such as job portals, company web sites, and

emails. It is no longer practical for these applications to be screened manually by most human resources departments or hiring managers. Consequently, automated resume scanning tools, also called automated tracking systems, are commonplace, many using natural language Processing (NLP) techniques to screen resumes as a first pass in the hiring process. In fact, this is not a new practice. Back in 2012, the Wall Street Journal reported that resume screening software was being used by around 90% of companies and it would be exceptionally rare to find a Fortune 500 company not using these systems (Weber, 2012). It is estimated that around 75% of resumes received by a company are never looked at by a human being (Bell, 2018).

Many of these automated tracking systems focus on the keywords in the position description and look for the exact same word in the applicant's resume. In the IT field, however, these words are constantly changing, whether it being new technologies such as DevSecOps or low code; new terms such as scripting or front-end/back-end developer; or new job descriptions such as data engineer or cyber threat hunter. In addition, there is little consistency between companies in how they describe the position requirements. For example, one may say Linux, others may be very specific about the Linux version, such as Ubuntu.

Currently many students who submit their resumes to job vacancies advertised on job sites such as Indeed simply do not get any response as their resumes are filtered out by the automated tracking system. Career service centers may help students strengthen their resumes in terms of format, language use, and human resource concerns, but their staff are less likely to answer questions as for what technical skills should be highlighted or which industry certification should be added to make the resumes stand out or match recruiters' criteria. Faculty members may review a student's resume and provide feedback and suggestions on enhancing his or her resume from the subject matter aspect, however, today's students are often reluctant to ask for help (Lammers, 2017). At our institution, we have developed various avenues to help the students prepare for the workplace as discussed in the introduction section. Although helpful for the students, these techniques are often not responsive enough to the students who want immediate responses and expect technology to help them get the answer.

So, we set about developing an automated tool that could help students help themselves and focus their resumes on specific aspects of their job search, based on what employers, and their automated tools, are looking for. It is based on using machine learning from a bank of advertised job positions in certain job categories, learning what and how these job skills are being described by the various organizations, and then matching the contents of a student's resume against them. A visual report of the analysis shows these results for the top job categories related to the student's resume, indicating how weighted the resume is towards each of these job categories.

The range of jobs selected for the study reflects both the focus of their education (such as cybersecurity) but also the background of many of our student population who are career changers or whose background experience is in jobs such as a camp counselor. Showing the weight of these factors is designed to help them focus on their intended career and to enhance their resume to reflect that, so increasing their ability to qualify for an interview for that first job.

3. METHODOLOGY

Overview

The overall process is shown in Figure 1.

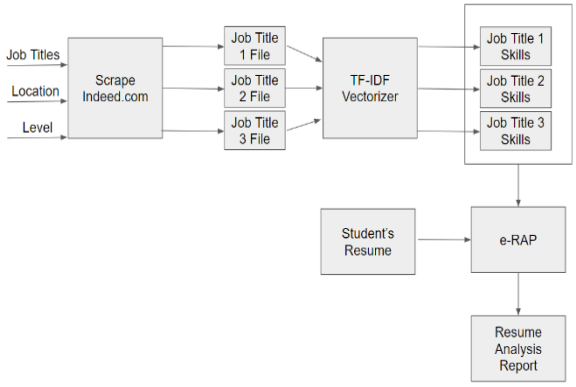

Figure 1 – The e-RAP Analysis Process

We first selected a set of job categories which were reflective of the students currently in the IT program, many specializing in cybersecurity. Some were designed to reflect the various aspects of the IT field and included 'Cybersecurity', 'Data Scientist', 'Software Engineer', 'Cloud Computing', 'Digital Writing', 'Management Analyst', 'Mathematician', and 'IT support'. Others reflected the other disciplines that were common in our career and major changers such as 'Economist', 'Nursing', 'Human Resources'', Financial Analyst', 'Psychologist',

and 'Biologist'. The final set was more reflective of the non-technical job experience that students may have had in high school and college such as 'Counselor' and 'Editor'. This initial set of job categories can be easily modified as the effectiveness of e-RAP is evaluated.

One thousand jobs per job category described above were harvested from Indeed.com (www.indeed.com). Indeed was the initial job board selected based on student's use and the fact that Indeed extracts postings from many job boards, company career sites, associations, and other sources of job postings. The job search was restricted to entry-level jobs in the local area to mirror the expected search criteria that the student would use in looking for an internship or a first job.

Next, the key topics and job skills were automatically extracted for each job category based on the job descriptions, eliminating terms that are common in all job description (e.g., EEO compliance). The initial extraction was based largely on single-word identification (e.g., data) with some compound words based on associations (e.g., quality assurance)

The text of each student's resume was then scraped and compared against these key topics and skills. A visual report of the analysis of the student's resume was produced showing the top 5 job categories represented in the resume. These 5 job categories are displayed on a percentage basis, indicating how weighted the resume is towards each of the job categories. It allows the student to see visually what job categories are most represented in their resume, whether that was their intended job focus or not. For each job category, a competency rating (expert level gets 5 stars and layman level gets 1) is displayed. Further, the report suggests 5 terms that are currently not in the resume that would bolster its relevance for that topic. For example, in a description of courses taken or projects conducted.

Data Curation

To create e-RAP we required two datasets, a set of current jobs and a set of resumes. To harvest current jobs, we created a web scraper for the job site Indeed.com. This scraper was programmed to take 3 parameters: a job category, a location, and a job expertise level. The output of the scraper was a job file with only the text from the relevant results. Each line of the file was a complete job description. We additionally cleaned the data by removing all HTML and JavaScript code automatically.

For this study, we restricted the search to jobs in the DC metro area and entry-level jobs only. This is the job profile for most of our undergraduate students as they graduate. For instance, our scraper created the file cybersecurity.txt by pulling the first 100 pages of a search for select parameters such as Entry Level Jobs in Washington DC for 'cybersecurity', capturing 1,000 jobs. Results for each job category scrape was then saved for analysis.

In order to compare these jobs with our student population, we collected an initial set of about one hundred undergraduate student resumes. A data extraction tool was programmed to extract any text in the resume as long as it was a .doc, .docx, or .pdf file. In cases where the student turned in a different format, we converted it to a pdf via a pdf printer.

Data Cleaning

Most job postings on Indeed.com contain basic boilerplate sentences for human resource language and basic company introductions. Generally speaking, this type of information is not of interest to our resume analysis. While a student might care about 401k and paid time off, e-RAP removes such language so that we can focus on attributes of the job posting that may translate well to a resume. To remove these terms from our evaluation, we hand-curated a list of 300+ common employment terms. In addition to human resource language, frequent words (the, is to, a, an) are not particularly useful for our analysis. These words are often called "stop words" and these stop lists come with many NLP kits. We removed all stop words from the job postings using NLTK's stop word list for English (https://www.nltk.org/). This same process was performed for the students' resumes.

After both the stop words and the employment terms were removed, we had a list of terms that mostly relate to job skills needed to fill the position. Our hypothesis is that these are the words useful for evaluation of a resume, and also would be positively reviewed by the automated tracking system if students included them to their resume.

Analysis Techniques

To compare a resume to a job posting, we created a process that would rank the relevancy of each job skill to a specific field. To do this, first we extracted the key terms. We conducted this extraction automatically using the common information retrieval technique of term

frequency–inverse document frequency (tf-idf). Tf-idf ranks the importance of a term to a document compared to other documents (Wu et al, 2008). Since all job posting for a job category were stored in a singular file and each job category has its own file, this was a fairly straightforward task.

Having a value for each term, we could turn each document into a vector of values representing the terms in the document. To find out if a resume is similar to a job category, we took the cosine similarity measure between the industry vector and a tf-idf vector for the resume. If the cosine value is equal to 1, they are the same document, if the cosine value is 0, the documents share no terms in common. (Tata and Patel, 2007). We compared a resume against each field tf-idf vector and reported the top 5 fields by similarity. These scores allowed us to show the distribution of the student's resume. For example, the top 5 job categories for a student's resume may be: Cybersecurity, Data Scientist, Natural Language Processing, Software Engineer, and IT Support. We went a step further and told the user the distribution such as 70% Cybersecurity, 20% Data Scientist, 5% Natural Language Processing, 4% Software Engineer, and 1% IT Support.

The student's weighted distribution will always equal 100% but just because 70% of the student's resume is focused toward a field does not make the student qualified. To provide this additional information we also give a star rating 1-5 based on how high the particular job similarity is to their resume. This helps adjust for situations that often happen in undergraduate programs where the student's main experience is still in high school level jobs, so while they focus on one job area, they do not have the coverage in that job area to be considered qualified.

The final part of our analysis gives suggestions for how to improve the resume. This is simply the top 5 terms for a given job category per tf-idf score that is not currently in the student's resume. This allows the student to make iterative changes to their resume and see the overall effect on our analysis. For example, if they see data, they can think back to their database class, reflecting on the tools that they used and any related project work.

4. INITIAL RESULTS

In this section, we illustrate the e-RAP results with three examples of the visual report produced and given to the student. In Figure 2, we first illustrate a student whose resume is very broad.

Figure 2: e-RAP Results for a Typical Early Undergraduate IT/Cybersecurity Student (see appendix)

In this example, the resume text is split across 5 areas fairly evenly, but the student is not an expert in any of them. This tells us that the student mentioned a few terms related to each job category but not specific enough to show any support for those skills.

In contrast, Figure 3 illustrates an IT student in the data science specialty that has some industry experience gained through a series of internships while in college.

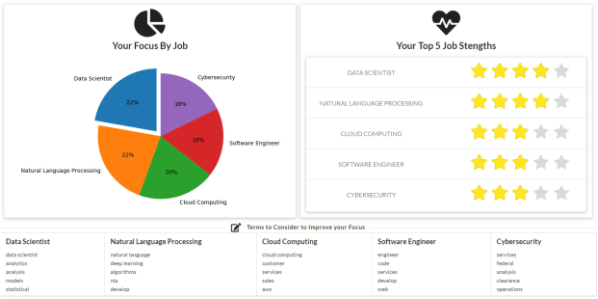

Figure 3 – e-RAP Results for an IT Student with Relevant Internship Experience (see appendix)

We see the resume still shows five areas that are all applicable to the student but the star ranking shows their true expertise. The student gets 4 stars for Data Science and for NLP (a subdiscipline of Data Science). If this particular student was hoping to get into cybersecurity, however, the student could see the list in the bottom right and see that it might be helpful to add any experience that dealt with services, federal, analysis, clearance, and operations. We can run pre- and post-tests where students

update their resume based on the feedback report, submit to the e-RAP tool, for a second report, and compare the differences and changes.

Finally, Figure 4 illustrates an IT student in the networking and cybersecurity specialty that has some experience gained through a series of research projects and an internship while in college. Her job strengths are strong in cybersecurity and in the related fields of software engineering, IT support, and data science. While management analyst represents a high percentage, it is at a lower skill level. The suggested words (e.g. federal) reflect the jobs in our region with a high percentage of jobs in the federal sector, government and government contractors.

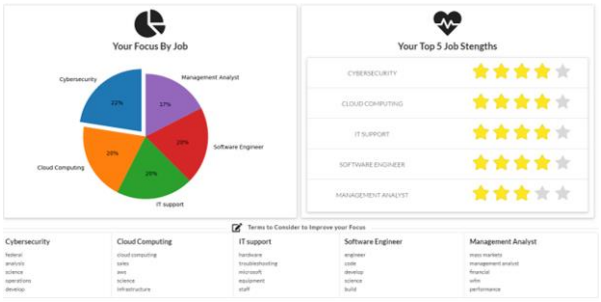

Figure 4 – e-RAP Results for an IT Student in the Networking and Cybersecurity Specialty (see appendix)

5. INITIAL EVALUATION

As an initial evaluation, we looked at how students can use eRAP to tailor their resumes before the intense job application process at the end of their senior year. To prepare them for the job search, students in their senior year are required to take IT423, the IT Senior Seminar. The one-credit course is designed to ensure that graduating students are ready for the workplace. They prepare a senior portfolio, highlighting their knowledge, skills, and experience in their targeted IT field. We took each of the submitted resumes (62 in all) and classified them into three categories:

1**. Cybersecurity**, 42 students (68% of total) with specialties including networking and cybersecurity, applied cybersecurity, cloud computing and forensic computing.

2. **Software Engineering**, 7 students (11% of total) with specialties including computer science or data science

3. **General IT**, 13 students (21% of total) with specialties including information systems or applied IT.

Of the 62 students, only 6 (less than 10%) had an emphasis outside IT when their resumes were analyzed by eRAP. This was largely due to the emphasis they had placed on their non-technical work experience: two in sales, two in counselling, and two as editors. Faculty will work with the 6 students and ensure they refer to technical content in courses and projects.

For the remainder, we looked at how the resume content related to their chosen specialty. In the cybersecurity category, one third of the students fell into the IT support field and are not sufficiently detailed about their cybersecurity knowledge. Review of these resumes shows that the students had no work experience to date in cybersecurity, and need to expand their coverage of cybersecurity courses and projects in their resume. Interestingly though, 3 students in the general IT category, had developed their resume to be predominantly cybersecurity.

This review demonstrated how we can build eRAP into the IT423 course to provide immediate feedback to the students. We will do this in the Spring 2020 semester and evaluate these results against the Fall 2019 results.

6. FUTURE WORK

To date, the analysis has been performed in the background, and faculty have reviewed the results. They are providing feedback to the system so that the e-RAP system can receive annotations on its analysis and thus improve the results. Once this has been concluded, a front-end will be developed so that the students can run the analysis themselves. Each time when they change their resume, the students would also obtain feedback provided by the e-RAP. Another future direction will be to delve into the individual cybersecurity jobs themselves as reflected in the NICE Cybersecurity Workforce Framework (Newhouse et al, 2017) and the Cyberseek cybersecurity pathways (https://www.cyberseek.org/pathway.html).

To our best knowledge, no such tool as e-RAP is made and employed in a university setting to help students sharpen their resumes from the skills angle. Some similar tools might exist in the

market, but most likely they are proprietary and not easy to access for college students. We will make it accessible to all of our IT and cybersecurity students. The ultimate goal is to extend this tool beyond these programs so that students from other programs can also access and have their resumes analyzed.

Finally, the authors recognize that they are in the early stages of success with this project. Even though an initial evaluation of e-RAP has been conducted and delineated in this paper, a more systematic and rigorous evaluation process to assess the effectiveness of the tool are under design and implementation. For example, we will have some human annotators rate the accuracy of the tool. We will also run a test where students look at the report generated by the e-RAP, change their resumes based on the suggestions, and run the e-RAP on the updated resume to generate a second report. We will have a review panel including our alumni working in the IT field or doctoral students with recruiting experiences to review pre- and post-versions of a student's resume and assess if the changes would increase their chances of being recruited. The ultimate goal is to make the e-RAP a live, fully functional tool that each of our IT and cybersecurity students can submit their resumes anytime for real-time, reliable feedback on resume enhancement so as to increase the likelihood of getting a high paying first job in their field of choice.

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Appendices and Annexures

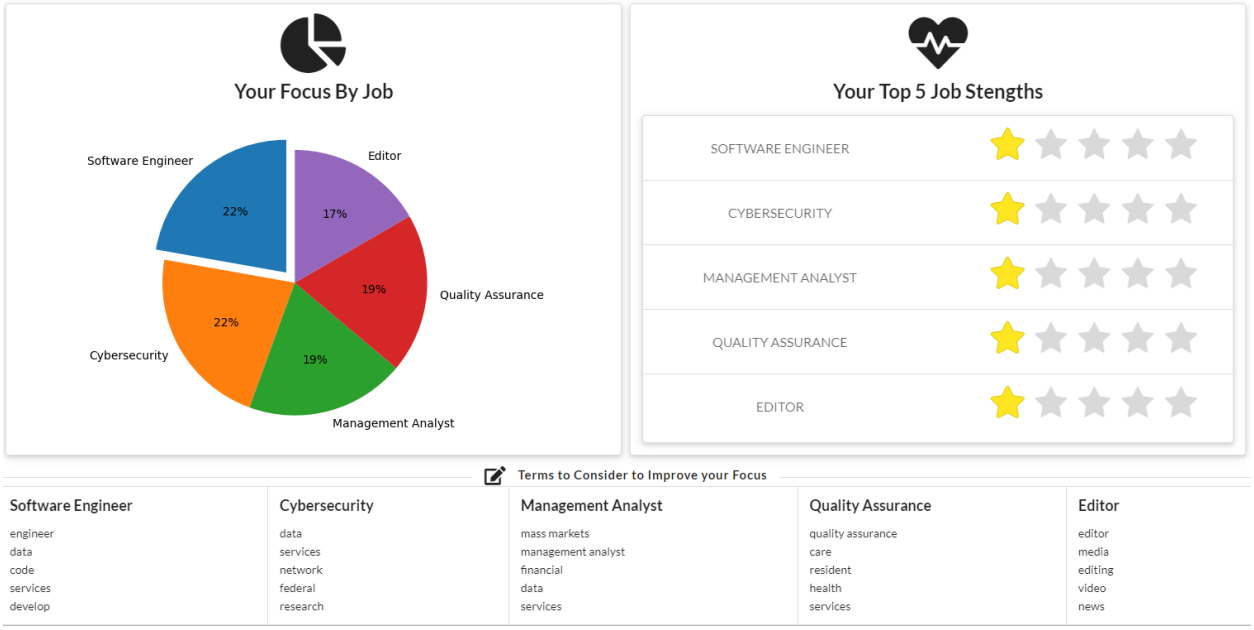

Figure 2: e-RAP Results for a Typical Early Undergraduate IT/Cybersecurity Student

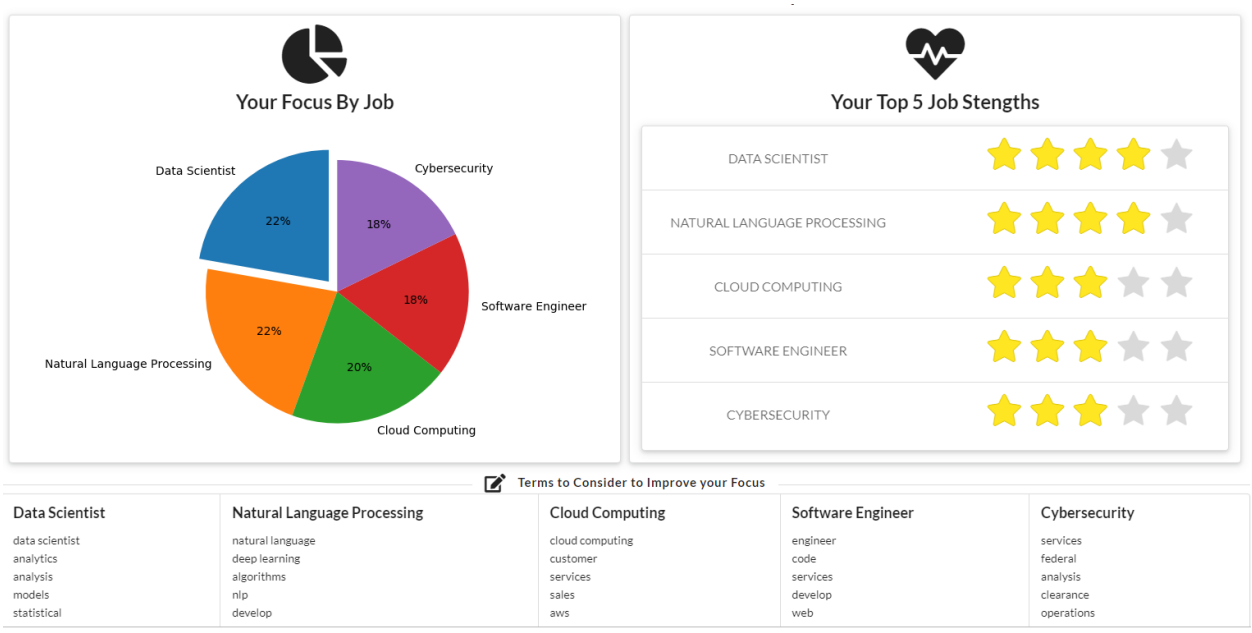

Figure 3 – e-RAP Results for an IT Student with Relevant Internship Experience

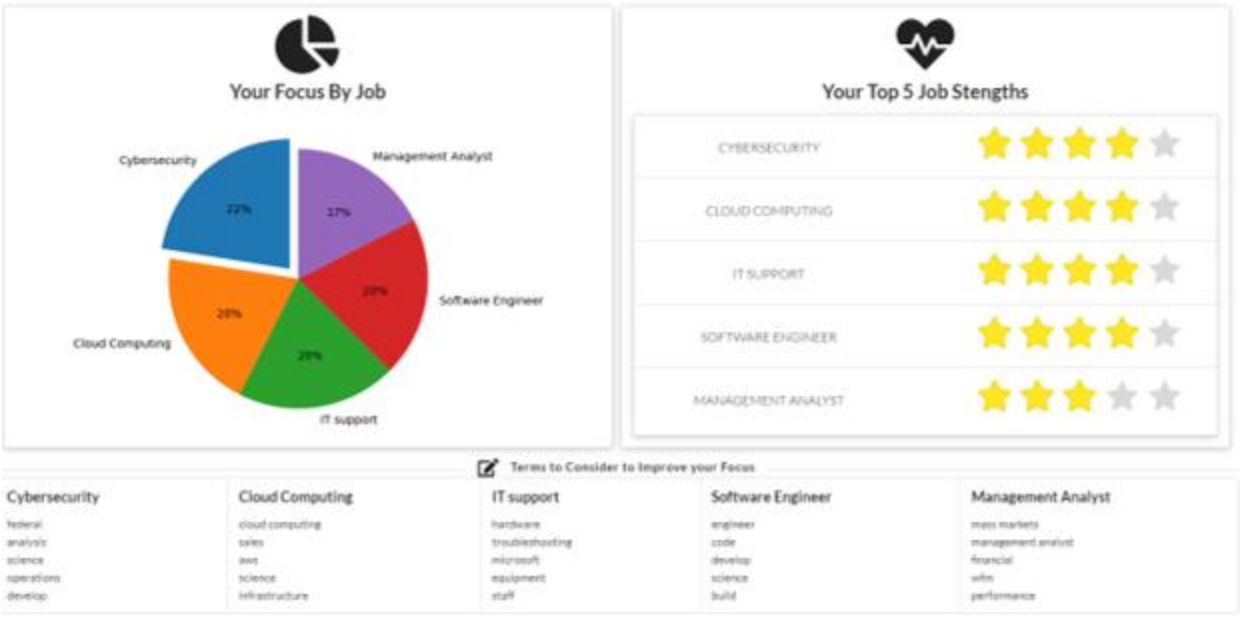

Figure 4 – e-RAP Results for an IT Student in the Networking and Cybersecurity Specialty

The use of short speculative fiction in teaching about privacy

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Abstract

This paper gives four examples of the use of short speculative fiction for teaching different aspects of information privacy. Information privacy is multi-faceted; as an area of study it intersects with a number of fields. A non-exhaustive list could include: law, information systems, decision science, marketing, management, philosophy, psychology, and sociology. The multi-disciplinary character of information privacy poses a challenge to teaching about it. Although using legal cases for teaching about privacy is valuable, the cases often involve disagreeable characters resulting in a distraction from the underlying privacy issue. In contrast, speculative fiction can present a privacy problem in a relatable context with a more agreeable set of characters. Students can imagine themselves in situations similar to those of characters in a short narrative through cognitive processes of transportation (by becoming immersed in the action) and identification (finding the characters familiar and sympathetic). I give four examples (four short stories) where I have used speculative fiction to teach some different aspect pertaining to information privacy. For each example, there is a plot synopsis, some suggested assignment with possible discussion questions, and an analysis of the key points within the fictional work and how they relate to key issues relevant to information privacy. The four fictional pieces are: Business as Usual by Pat Cadigan, Scroogled by Cory Doctorow, The Perfect Match by Ken Liu, and Water by Ramez Naam.

Keywords: information privacy, surveillance, speculative fiction, theory of mind

Teaching about information privacy is challenging. One reason is that it draws from a number of disparate fields including: law, information systems, decision science, marketing, management, philosophy, psychology, and sociology. Within the legal environment, privacy is a contested term. Is it a right? See Solove (2008) for a thorough analysis of the problems in defining privacy. Nonetheless, accompanying modern society's increased dependence on data usage and data sharing has been an increased frequency of harmful events involving personal information leading to a growing recognition of the importance of privacy.

Many legal cases illustrate a particular problem in teaching about privacy. Cases often involve someone who has apparently committed a crime. The evidence provided by the state may have been collected illegally, without a warrant for example, and thus in violation of the 4th Amendment of the U.S. Bill of Rights that protects against unlawful search and seizure. Sympathy may naturally reside with law enforcement; after all bad guys should be put in jail. Furthermore, for many students it is difficult to relate to the defendant in these cases. This paper advocates the value of using speculative fiction for teaching about privacy. This genre of fiction can present a privacy problem in a relatable context with a more agreeable set of characters. Students can imagine themselves in situations similar to those of characters in a short narrative through cognitive processes of transportation (by becoming immersed in the

action) and identification (finding the characters familiar and sympathetic).

As with business cases, well-chosen speculative fiction can provide rich (complex, partly ambiguous, generally realistic) problems. A well written case can be presented from the standpoint of a decision maker with a problem. This enables the student to place herself in the position of the decision maker in resolving the problem at hand. Unlike business cases written with a pedagogical objective, fiction written for entertainment can also enable identification with the characters who are faced with unique situations and forced to resolve some problem. Fiction can also share with case studies the quality of being a good vehicle for participative learning through in-class or online discussions. Margaret Atwood describes some of her work as speculative fiction in contrast to science fiction. She is quoted (Potts 2003) as saying, "Science fiction has monsters and spaceships; speculative fiction could really happen." For these reasons, the use of speculative fiction is valuable for inclusion within a stand-alone course on information privacy or as a module on privacy that could be included within a number of courses in various business disciplines.

I give four examples (four short stories) where I have used speculative fiction to teach some different aspects pertaining to information privacy in a Masters level class. For each example, I provide a plot synopsis, some suggested assignment with possible discussion questions, and an analysis of the key points within the fictional work and how they relate to key issues relevant to information privacy. The four fictional pieces are: Business as Usual by Pat Cadigan, Scroogled by Cory Doctorow, The Perfect Match by Ken Liu, and Water by Ramez Naam.

1.0 FOUR SHORT STORIES

Business as Usual by Pat Cadigan (Cadigan 2014)

Synopsis. Cara, the protagonist of 'Business as Usual' works for LifeCandy, the premier interface design company. She supports the module that runs refrigerators. She became interested in interface design for the Internet of Things because of the end of life experiences of her grandmother, Nonna who thought her insulin pump was trying to do her harm. Home refrigerators along with other appliances are run by a home hub that interfaces with an insurance company that has instituted something called Healthy Home, a system that monitors food intake and enforces healthy eating by restricting access to the refrigerator. Cara has a disturbing interaction with a refrigerator one evening when she receives a call on her dedicated help line. When she is called in to see her supervisor the next day, she infers that her toilet has snitched on her. In the end, she, under the supervision of Life Candy management, come to an organizational accommodation for the buggy AI that runs Healthy Home.

Assignments. 'Business as Usual' works well for in-class discussions, essay assignments and online forums. Some useful discussion questions follow.

1) What means of surveillance described in the story do you find most realistic and threatening, and why?
2) What is the threat posed by the Internet of Things as a surveillance medium as described in the story? Are there aspects of IoT that you have encountered that are personally concerning?
3) The story illustrates an intrusive collaboration among various stakeholders in the healthcare space (e.g. health care providers, insurance companies, big pharma). How realistic is this? How concerning?
4) The story describes a fairly passive view of loss of privacy. In his seminal article that coins the phrase "ubiquitous computing," Mark Weiser states, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." How is that illustrated in the story?

Scroogled by Cory Doctorow (Doctorow 2007)

Synopsis. After vesting out of Google, Greg takes a several months-long vacation to Mexico. Upon returning, he discovers some changes to the USA's immigration process – Google has partnered with the Department of Homeland Security to provide information about people entering the country. After a rudely invasive interrogation, he is finally passed through security. Still agitated from his experience at Customs, he seeks out and meets with a former co-worker and discovers the extent of the collaboration between Google and the government and in particular the wide ranging information they have about him. It turns out that his colleague has been developing something called Google Cleaner that will cull

incriminating information from Google's databases. The two of them sanitize Greg's digital dossier which provokes a reaction from a quasi-governmental group.

Assignments. The 'Scroogled' story is a good source for either an in-class discussion, an online discussion forum, or an essay. Some interesting discussion questions include:

1) Since this is fiction, some aspects of 'Scroogled' do not conform to reality. What parts of 'Scroogled' do you consider to be true; what parts are a slight stretch; and what parts are unrealistic?
2) Which amendments in the US Bill of Rights are implicated in the 'Scroogled' story?
3) Discuss the following quote from the story, "Recently, the site's search-optimization software had begun using the data to tailor Web searches to individual users. It proved to be a revolutionary tool for advertisers. An authoritarian government would have other purposes in mind."
4) This article from *Ars Technica* (Amadeo 2017) discusses Google's linking of email contents to ad servers. In addition, it links to a Microsoft advertising campaign for Outlook. Discuss any ethical issues raised by this article and the Microsoft ad campaign.

The Perfect Match by Ken Liu (Liu 2012)

Synopsis. Sai works as a paralegal assistant for a prestigious law firm. His largely mediated life is managed by 'Tilly' a virtual concierge who takes care of all his needs from waking him up in the morning to the perfect wake up music "…the rousing first movement of Vivaldi's violin concerto in C minor, "Il Sospetto," to arranging dates with a new girl, "I'm sure you'll like her. The compatibility index is very high. I think you'll be in love for at least six months." Tilly knows Sai's moods and tastes better than anyone. Tilly is produced by Centillion whose mission is to "…arrange the world's information to ennoble the human race," and has the motto, "Make things better!"

When Sai leaves his apartment he has an argument with his next door neighbor Jenny who is putting tape over the lens of his security camera. She doesn't want Tilly observing the comings and goings of her friends. Jenny's parting shot to Sai as he heads to work is, "Tilly doesn't just tell you what you want … she tells you what to *think*. Do you even know what you really want any more?" When Sai's date doesn't go too well – everything went too smoothly, no surprises, no thrill of new discovery, a somewhat boring date, Sai turns off Tilly.

As he arrives at home, he encounters Jenny again. She invites him into her apartment, but not before she puts his phone into a Faraday pouch – her apartment is equipped as a Faraday cage. Thus begins Sai's education into the nefarious attributes of the surveillance economy and his radicalization. Jenny explains that the biggest threat to Centillion is the corruption of their data on a broad scale. This would render their personal prediction unreliable and as a consequence their advertising revenues would dry up. They hatch a plot that involves Sai's employer whose client is the CEO of Centillion.

Assignments. The Perfect Match provides a good basis for discussing many of the issues covered in *Surveillance Capitalism* by Shoshana Zuboff. I introduce material from this book in the class. The following questions could be used in either an online or in class discussion or as an essay assignment.

1) Jenny's strategy to take down Centillion involves the corruption of their data. Browser add-ons TrackMeNot and AdNauseum both rely on obfuscation. TrackMeNot protects against search engine profiling by using a PC's idle time to send out random queries. AdNauseum employs a similar strategy by automatically clicking on all blocked ads registering a visit on ad networks' databases. AdNauseum has been booted from Google Play. Is this recognition by Google that obfuscation is a viable threat to their user profiling?
2) One part of Google's business model is to generate ad revenue by using big data and algorithms to profile individuals. A second approach is called economy of action – system attributes that channel attention and action in a manner that alters people's behavior in a predictable way. These could employ conditioning or nudges to influence behavior. How does Tilly aim to create economies of action?
3) At one point Jenny says, "Years ago, they caught Centillion's traffic-monitoring cars sniffing all the wireless traffic from home networks on the

streets they drove through. Centillion also used to override the security settings on your machine and track your browsing habits before they shifted to an opt-in monitoring policy designed to provide better 'recommendations.' Do you think they've really changed? They hunger for data about you—the more the better—and damned if they care about how they get it." What are some parallels to legal issues involving Google or Facebook attempts to skirt privacy law in the US and the EU?

4) At one point Sai attempts to turn Tilly off. It turns out that Centillion has installed a failsafe switch preventing this. How is this like attempting to uninstall Google Play from Android systems? How does Google take advantage of the presence of Google Play to ensure their ability to gather user data?
5) In the story, Christian Rinn, Founder and Executive Chairman of Centillion quotes Winston Churchill as saying that we shape our buildings, and afterwards, our buildings shape us. We made machines to help us think, and now the machines think for us. How well does this analogy work to enable us to understand our relationships with information and communication technology?

Water by Ramez Naam (Naam 2013)

Synopsis. Simon, the senior marketing executive for the Pura Vita food group, meets Stephanie, a college acquaintance, for lunch. They live in a world dominated by the attention economy and its relentless advertising. Nexus Corporation holds patents on neural implants that provide enhanced intelligence, a photographic memory, immersive entertainment options, a direct connection with your loved ones, and other cognitive benefits. The only catch was if you can't afford the implant, you could get one in exchange for being served advertisements and receiving neural stimulation associated with the pleasure of using a particular product, designer water for example.

Simon is anticipating a hook-up with Stephanie so he turns on the full and subtle power of his feed into her implant. However, she has other plans. As they part, she attaches a nano bot that contains a worm to the back of his jacket. The nano bot infects the Pura Vita AIs that run all their marketing and supply chain systems. Once the worm penetrates the Pura Vita IT, Simon's downfall becomes inevitable and irreversible.

Assignments. 'Water' can be used like the previous three stories, as a source for in-class or online discussions. Some potential discussion questions are:

1) How does the manipulation of attention and desire in this story illustrate the privacy paradox – that people are willing to trade their privacy for various conveniences?
2) Discuss how the internal dependencies of economic systems such as stock markets and supply chains pose a risk so that triggering events such as a hack of critical systems can cause them to spin off beyond the control of human beings.
3) Marketers claim Americans give out information about themselves as a tradeoff for benefits they receive. However, an Annenberg survey shows Americans don't believe the trade-off is a fair deal (Turow, Hennessy, and Draper 2015). What are the arguments put forth for the two sides and how are they illustrated in 'Water'?
4) Brandon Fischer of GroupM Next consultancy predicted that by 2028 half of all Americans and by 2054 nearly all will have device implants in their bodies that communicate with retailers as they walk down store aisles inspecting various products. Implants will also read emotional states as you examine these products (cited by Turow 2017, p. 2). Do you think his prediction is likely to be close? What factors do you think there are that would induce people to accept device implants? How does this prediction affect the believability of this story?

2.0 RESULTS

Students were able to relate to each of the stories. Some of them produced essays that included a number of personal observations. For example, some essays written about 'Water' included detailed discussions of behavioral advertising and their experiences as targets. One student who was engaged to be married described the push of Facebook ads for wedding rings on her homepage which she related to the behavioral advertising in the story. Several commented on a simulation within the story that showed Stephanie slimmed down and fashionably dressed in the display window of a clothing store. One essay described the

student's participation in an Attention Deficit Workshop where she donned some sensory deprivation technology in order to understand the experience of ADD. She compared that experience with the sensory bombardment described by the characters in 'Water'.

Students' write-ups of 'Business as Usual' also provided examples that suggested a high degree of engagement with the narrative and identification with the characters. One student connected multiple parts of the story with the line from Bob Dylan's song (Ballad of a Thin Man), "And you know something's happening, but you don't know what it is. Do you Mr. Jones?" Several students commented on the virtual assistant Glinda and compared her (it) to Amazon's Alexa and Apple's Siri. They were particularly appalled at Glinda's capability of integrating data from the toilet with data from the refrigerator to infer that Nonna was not following the appropriate diet. They also objected to surveillance from the health insurer that took data from Nonna's insulin pump and fed it to the refrigerator. One student wrote, "Suddenly we find ourselves answering to refrigerators. We find ourselves with software taking the initiative…We find ourselves with mandatory healthy home as part of our coverage." Another student wrote, "I am a Nonna and can see myself acting this way in the future."

3.0 DISCUSSION

Privacy entails the forces of government(s), the private business sector, culture, and technology (broadly conceived) all affecting the individual in that the effects of privacy invasions or privacy harms are borne by the individual. This can lead to resignation and the belief that there is no longer any privacy. There are myths to support such rationalizations such as "In order to have security, you have to give up privacy." or "If you haven't done anything wrong, you have nothing to worry about." In the face of privacy in the news, it may be easy to conclude that "The real threat to privacy is government" or "The real threat to privacy is business." These commonly held viewpoints are obstacles to teaching about privacy. Another obstacle occurs because privacy as a concept draws on many disciplines. Its salience has increased because of developments in the area of information and communication technology (ICT), namely the capabilities of capturing data, storing it in a database, and sharing across networks. The dynamic changes within ICT take place within a complex legal regime, increasing globalism that affects business, and dramatic cultural change. Instead of parsing the complexities of each of these fields and then synthesizing them into a coherent set of abstract presentations, fiction works here by providing a narrative form that integrates many features from these source fields.

Oatley (2016) describes the processes that take place when reading fiction as social simulation. Rather than thinking of fiction as an imitation of life it is more productive to think of it as a simulation that functions to enable the exploration of peoples' minds and their complex interactions in different social worlds. The capability of identifying and understanding another person's mental states is referred to as Theory of Mind (ToM). This capacity for understanding another's subjective states is important for navigating and maintaining complex social relationships. ToM consists of two parts, affective (the ability to read another's emotions) and cognitive (understanding a person's beliefs and intentions). ToM enables a person to function effectively in complex social environments and is a source of empathy (Kidd and Castano 2013).

Reading fiction has been found to be a source that provides improvement in empathy and ToM more generally. (See Bal and Veltkamp 2013, Rowe 2018 for reviews of this literature.) But how does it work? There are two processes at play, transportation and identification. While reading a fictional narrative people may become so immersed in the story that they are absorbed or transported into the world presented in the narrative. This state of absorption is sometimes referred to as getting lost in the book. Bal and Veltkamp cite literature that shows that it is the mental journey taken by the reader that brings about change. When readers become transported into the narrative and emotionally identify with the characters, personal change and in particular increased empathy occurs compared to those readers who did not experience transportation. A second process involves the inferences the reader may make about the character, beliefs, and intentions of one or more of the persons portrayed. These are the sorts of inferences people make during conversations in determining the character or personality, and intentions and beliefs of the conversation partner. The transportation process corresponds to the affective part of ToM and the inferential process is the cognitive part.

Oatley (2016) makes the case that reading fiction is cognitive simulation because areas of

the brain activated by reading fiction are identical to those activated for the same cognitive processes in the daily life of the reader. The environment where privacy problems play out is ambiguous, rapidly changing, and ethically challenging. The introduction of fiction into this complex landscape opens the potential of enabling students to mentally experiment with what is likely an unfamiliar environment. They may find it easier to empathize with characters in a fictional account than with the often odious defendants in legal cases. In general simulators have the advantage of providing a venue for low cost rapid experimentation with realistic scenarios. Learning to fly an airplane, especially one that is complex is made much safer and effective through the use of simulators. There is an apt analogy for the use of speculative fiction for learning about the complex and risky worlds where our privacy is at stake. As the Margaret Atwood quote shows, this is fiction about things that could really happen thus making it fertile ground for cognitive simulation.

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Editor's Note:

This paper was selected for inclusion in the journal as an EDSIGCON 2019 Meritorious Paper. The acceptance rate is typically 15% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2019.

Student Perceptions of Challenges and Role of Mentorship in Cybersecurity Careers: Addressing the Gender Gap

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Abstract

The cybersecurity industry is facing a significant shortage of professionals to fill open positions, with a projected staffing shortage of 1.8 million jobs worldwide by 2022. Part of this shortage can be attributed to the underrepresentation of women in the field. This research addresses the gender gap in cybersecurity by exploring the perceptions of students in cybersecurity programs about the differences between men and women in terms of the challenges they will face in pursuing a career in this field and the role of mentorship in attracting and retaining professionals in the field. Researchers conducted a set of focus groups with a total of 25 students to explore these issues. A key finding indicates that while stereotypes of a male-dominated field and gender-related challenges still exist, no gender difference or bias was reported or observed by students in their classes or workplace internships. Another key finding notes that students found peer mentorship to be one of the most valuable aspects of their cybersecurity programs and aspiring careers in the field. A set of recommendations is presented to aid in addressing all challenges identified and to suggest solutions for improving mentorship opportunities.

Keywords: cybersecurity, gender gap, mentorship, peer mentoring, qualitative, focus group

1. INTRODUCTION

Cybercrime and other cyberattacks continue to increase in number, complexity, and sophistication. Addressing this issue is one of the most critical needs within the information technology (IT) field. However, the cybersecurity industry is facing a significant employment gap, with unfilled positions across all areas of the cybersecurity field. There are over 313,000 cybersecurity-related job openings in the United States in 2019 ("Cybersecurity supply/demand heat map", n.d.) and Forrester projects a staffing shortage in cybersecurity of

1.8 million jobs worldwide by 2022 (Balaouras, 2018). Another serious concern is the underrepresentation of women in the field (Richter, 2019; Morgan, 2019; Higgins, 2018; Peacock & Irons, 2017; LeClair, Shih, & Abraham, 2014; Bagchi-Sen, Rao, Upadhyaya & Chai, 2010). The most prominent report that is often cited in the media asserts that women make up only 11% of the cybersecurity workforce (Frost & Sullivan, 2013), even though women represent approximately 50% of the overall workforce (Richter, 2019; LeClair, Shih, & Abraham, 2014). However, more recent reports place the number of women in cybersecurity at 20% of the workforce, which shows a definite improvement, but is still too low (Morgan, 2019; Higgins, 2018). In the past eight years, there has been a steady rise in the number of STEM-related degrees earned by female students. There was a 48% increase for females from 2008 to 2016, while males earning STEM-related degrees saw a 38% increase in the same time period (Feldman, 2019). This is encouraging and indicates further movement toward closing the cyber gender gap, though the gap still persists.

There is a strong need to explore the full range of factors that may influence women in their decision to consider or maintain a career in cybersecurity (Schumba et al., 2013). Research has shown that addressing the needs, concerns, and motivations of women potentially interested in the field of cybersecurity while they are at university is crucial to their successful entry and future success in the field (Bagchi-Sen et al., 2010). Other studies show that connecting women with cybersecurity early on, such as through the Girl Scouts' cybersecurity badge or free online classes, can be beneficial in engaging them with the field (Higgins, 2018). Further research has also been called for to understand the importance of mentors or role models on the retention of females in the cybersecurity industry in particular (Higgins, 2018; Willis-Ford, 2018).

A critical review of the research literature in the domain of women in the cybersecurity field reveals an urgent need to address the employment and gender gap in the field. It is necessary to understand the challenges for female students pursuing cybersecurity careers and how they might differ from male students. It is also important to explore the perceptions of female and male students about the role of mentorship in regard to the field, as this may be a useful way to engage and retain female students in particular (Balaouras, 2018; Higgins, 2018). This study explores the challenges encountered by college women and men pursuing careers in cybersecurity programs and their views on the role of mentorship. To this end, three research questions were developed:

RQ1: What challenges do students face when pursuing a career in cybersecurity?

RQ2: What are students' perceptions about the role of mentorship when pursuing a career in cybersecurity?

RQ3: What differences exist between men and women regarding the role of mentorship and challenges faced when pursuing a career in cybersecurity?

2. LITERATURE REVIEW

Challenges for Women

Women face challenges when seeking cybersecurity positions. According to a study conducted by D'Hondt (2016), barriers for women pursuing a career in cybersecurity consist of militaristic/male-gendered culture and stereotypes, recruitment practices from companies, bias in the hiring process, and branding. When explaining the militaristic/male-gendered culture stereotypes, D'Hondt (2016) discusses the dominance of men that appear in movies or television shows about cybersecurity or hacking. Women are rarely included in these roles in shows but when they are, their characters are often portrayed as "goth" or something out of the everyday norm for a work environment. In the education environment, women are often ignored in group projects or are marginalized.

In order to overcome the recruitment barrier for women that want to enter the cyber field, it might be beneficial to have women recruiters. When it comes to bias in the workplace, since the majority of technology positions are held by men, men often hire others that are very similar to them. Having both women and men recruiters could help solve this bias issue. Lastly, organizations need to brand their marketing material to be gender inclusive. How job announcements are worded can make a difference in who actually applies for the position (D'Hondt, 2016).

A Kaspersky study (2017) surveyed 4,001 young people between the ages of 16 and 21 in regard to why women are not choosing careers in cybersecurity. The study revealed that 57% of women believe they lack coding experience,

52% do not have an interest in the career, and 45% did not know enough about cybersecurity careers. Of those surveyed, only 16% of women even knew what a cybersecurity expert does in their job, as compared to 20% of men. The issue comes down to awareness. Women do not have to be coders to be able to succeed in a cybersecurity career. One solution that Kaspersky lists is that women need to be highlighted more as technical role models in imagery and in the media. One in six women believes that the field of cybersecurity would be dull.

Role of Mentorship

Interviews conducted by D'Hondt (2016) revealed that mentorship is a key part of retention for both women and men in the cybersecurity field. Mentorship programs contribute to employees staying in the field longer. Companies should encourage both formal and informal mentoring programs. Starting with a small group of employees willing to participate and mentor new hires would be a great start. It helps, but is not necessary, to pair a woman with a woman mentor to advocate on their behalf. A study conducted by Frost and Sullivan (2017) revealed that 28% of women in cybersecurity feel that their opinions are not valued. Women who felt that their opinions were valued, 61%, indicated that their organizations provided adequate training, leadership development, and mentorship.

A study conducted by Glass (2013) shows that a lack of mentors is an important factor in few girls studying cybersecurity in middle school, high school, and at the collegiate level. If the mentor projected a stereotypical image of a "geek or nerd", girls were less likely to believe in their success in the field. The success of role models for young women is needed to help girls succeed in cybersecurity.

Willis-Ford (2018) conducted a quantitative study to gain an understanding of why women have a lower retention rate than men in the cybersecurity industry. As part of the study the author analyzed the impact of mentorship or lack thereof. The lack of mentors for women in cybersecurity is an important factor contributing to low retention rates of women in STEM. LeClair, Shih, and Abraham (2014) indicate that while equal pay and advancement opportunities are important for the retention of women in cybersecurity, having mentors is more important. The mentor does not need to be female but needs to have an interest in the mentee's success.

Cheryan et al. (2011) found there to be no difference between male or female recruiters in the STEM field but found that women mentors are more effective for keeping women in the field.

Research is split as to whether gender matters when mentoring women entering the field of cybersecurity. A factor that must be noted is that female mentors are more difficult to find due to the gender gap in the field of cybersecurity.

3. METHODOLOGY

A focus group is a small-group discussion guided by a facilitator. It is used to learn about opinions on a designated topic, and to guide future action (DeVault, 2018; Krueger & Casey, 2000). Focus groups are a common qualitative data collection method where the data is collected through a semi-structured group interview process. The focus group is a gathering of deliberately selected people who participate in a planned discussion intended to elicit perceptions about a particular topic or area of interest in an environment that is nonthreatening and receptive (DeVault, 2018; Krueger & Casey, 2000). It asks participants for open-ended responses conveying thoughts or feelings. The focus of our research is exploratory in nature, exploring the perceptions of current students in cybersecurity programs; therefore, we believe this method is appropriate.

After approval of the research by the university Institutional Review Board, we conducted three separate focus groups with a total of 25 participants. Students enrolled in a cybersecurity program at the researchers' university (approximately 189 students) were invited to participate in one of three focus groups in February 2019. The first focus group had four students (2 males, 2 females) participate. The second focus group had 10 students (8 males, 2 females) participate, and the third focus group had 11 students (9 males, 2 females) participate. The same semi-structured protocol was used for all three focus groups and we audio-recorded each of the sessions. Each focus group was led by at least one facilitator and included at least one note-taker. Each session was about 45 minutes long.

Audio recordings were transcribed and reviewed for accuracy. Thematic analysis of the data was done manually first by each member of the team. Next, teams of two developed the various themes. Then, the themes were verified by all four members of the team.

4. RESULTS

Challenges in Pursuing a Career in Cybersecurity

The first research question was (RQ1) What challenges do students face when pursuing a career in cybersecurity? This question was proposed to the participants without any leading comments or introduction suggesting that there may be a gender gap within the field. Data analysis for RQ1 suggests three themes: Need to keep learning to adapt with quickly changing technology, Male-dominated profession, and Challenging field with much responsibility (see Table 1).

Themes for RQ1	M	F	Total
Need to keep learning to adapt with quickly changing technology	8	10	18
Male-dominated profession	9	4	13
Challenging field with much responsibility	2	3	5

Table 1: Code frequencies for themes relating to perception of challenges in cybersecurity careers by gender

Participants noted that cybersecurity is a quickly changing field and constant learning of new technological solutions is required. A few participant quotes to illustrate this theme were:

"You constantly have to learn new ways, because there are people out there that are finding new ways to do things."

"It's constantly reforming itself and you constantly have to keep learning and learning and that alone is gonna be a challenge for not just me but for every other person going into the cyber world as a career."

Related to this concept was the theme that cybersecurity is a challenging field with much responsibility. The participants acknowledged that the field can be intimidating for many students and that there is added pressure on professionals in this field because it comes with a great sense of responsibility for protecting organizations, individuals, and data. Some responses included:

"You just gotta set your mind to it. But it was daunting at first."

"It's a huge responsibility."

Cybersecurity is a male-dominated field is another theme in this study. The participants in the focus groups agreed that there are fewer women in cybersecurity than men. They expressed the viewpoint that this may have to do with pre-existing stereotypes that the field is more suited to males, even though they see this issue changing. Participants said:

"So it's always a stereotype thing and you never see it as a female role because it's almost always masculine, if that makes sense."

"And it's not so … I feel like companies definitely want to start bringing in women so that they can get out of that direction, but um, I feel like companies felt that men are better in this career than women are."

Role of Mentorship

The second research question (RQ2) was: What are students' perceptions about the role of mentorship when pursuing a career in cybersecurity? This question addressed perceptions of the role of mentorship as participants prepare for a career in cybersecurity, and secondarily explored perceptions related to gender of mentors. Participants did not mention any gender roles for mentorship (e.g. whether gender of a mentor would impact the quality of the mentoring relationship) until they were expressly asked by the researchers. This was telling in that it was not something that occurred to the participants as an issue or consideration when thinking about the role of mentorship.

Mentorship resonated with the focus group participants and various facets of mentorships were identified in the data analysis. The main emergent themes are: Peer influence, College professor/school teacher influence, Cybersecurity-focused student club influence and Family or friend influence (see Table 2).

Themes for RQ2	M	F	Total
Peer influence	5	5	10
College professor/school teacher influence	3	7	10
IT-focused student club influence	4	5	9
Family or friend influence	2	1	3

Table 2: Code frequencies for themes relating to perception of the role of mentorship for careers in cybersecurity by gender

Our results suggest that the most important type of mentoring is the one that these students are getting from their peers. This is evidenced by the combined results in the "peer influence" and "IT-focused student club influence" categories, which both address types of influences from other students.

Peer influence is a great way of learning and teaching fellow classmates about technology in an informal and relaxed environment. Participants said:

"I think a lot of my mentors have been previous students, as well as people who are my peers right now."

"I don't know if it's more direct or indirect. I would say it's more indirect in just seeing what other people have accomplished so far and being able to talk to them and just getting some information."

"… and when you do trial and error with a partner and you finally figure it out. Just the feeling is… like, you know what you're doing now."

Mentorship from professors or school teachers also emerged as an important factor in helping students develop a grasp of professional roles and its expectations in real world settings. Students benefitted from learning from professors and seeking advice from them. Many of them were influenced by school teachers to develop an interest in cybersecurity in the first place. Participants illustrated this theme by saying the following:

"Two of my biggest mentors here at [university]… and those two have guided me and like taken me under their wing so to the point that I'm like, I feel prepared…"

"Not only does she care about her students in the classroom, but she also cares about her students outside of the classroom."

"…even with that, she gives you so many opportunities for internships, she'll setup tours, I mean like, she's just phenomenal if you're like, trying to do something with this major. Hands down."

"…um, I talk to him a lot about like getting into the FBI and what to expect."

Participating in a cybersecurity-focused club played an important role in developing confidence for these aspiring cybersecurity professionals. An opportunity to engage with experts in the industry or participate in competitions provide a unique perspective to students about the careers they are hoping to achieve. Participants noted:

"If you are not in [club name] yet and you think it's a sham, you're wrong."

"The connections that everybody has and I think after going and touring a couple of these places and touring with [club name], you learn that the field is more connected than any other field."

"… what you're not getting in the classes. It opens more for you."

Family and friends also play an informal but crucial role in shaping the perceptions and expectations of students from themselves and from the industry. A participant stated:

"One person told me that where the future is headed is IT security and that's the reason why I got into it."

It is clear that while many professors, teachers, family members, and friends were counted among the mentors identified by the participants, peer mentorship was key for them. A cybersecurity-focused student club was pivotal for many of the participants in achieving this high level of community and mentorship amongst their peers.

Differences between Men and Women

The third research question (RQ3) stated: What differences exist between men and women regarding the role of mentorship and challenges faced when pursuing a career in cybersecurity? This research question was analyzed by looking at themes for any underlying differences in male and female perceptions in terms of challenges and mentorship in cybersecurity careers. The focus was to understand if the participants see any difference in challenges for males vs. females or if they had preconceived ideas about male mentorship vs. female mentorship. Three themes emerged in this context: Gender not an issue for job tasks, More pressure on women to show confidence, and Gender unimportant for mentorship (see Table 3).

Themes for RQ3	M	F	Total
Gender not an issue for job tasks	3	6	9
More pressure on women to show confidence	3	2	5
Gender unimportant for mentorship	1	2	3

Table 3: Code frequencies for themes relating to gender differences in perceptions of challenges and the role of mentorship in cybersecurity by gender

When asked if gender differences were perceived in terms of job tasks in the workplace, participants, both males and females, agreed that there were no differences. These views were expressed by participants:

"My entire team, I am one of 3 males on a team of 18. Um, my manager is a woman, my manager's manager is a woman. Our security operations manager is a woman… I don't see any difference between males and females in the workplace at all." (Male participant)

"No, I've never been treated differently than a male would. Especially my internship or classes, nothing." (Female participant)

"…I don't think there's a gender, um, problem there. Again, women can be just as successful in this field as men can." (Male participant)

"I didn't see any difference between males and females in the workplace at all. Every single person's treated equally, completely, and we all get pretty much the exact same amount of work." (Male participant)

These results suggest that our participants' perception is that if there are women on the team, they are treated just like males on the team and given similar opportunities to take responsibilities. Even though these participants are primarily students that are yet to enter the workforce officially, most of them work as interns in the cybersecurity field and have observed and experienced a corporate environment closely. The women in the group did not feel discriminated based on their gender, in their limited experience in industry work culture. This is a healthy sign and shows promise for young generations feeling less burdened by gender stereotypes and more into direct competition with their peers irrespective of gender.

Despite this view, both male and female participants agreed that in similar roles in organizations, women feel more pressure to perform and deliver and be more confident in their day-to-day interactions than their male counterparts. Participant statements that illustrated this point included:

"I can only for myself, but you have to have that level of confidence and not even a sense of arrogance, but like a real sense of confidence within yourself saying I can do just as much as you if not more." (Female participant)

"…and the managers would always watch her closely and so she always felt like she had something to prove, which would always make her work harder." (Male participant)

"…but it's almost like they watch them more. Like they just watch the women more… to see if they are really better. Which, I don't think it should be like that, but that's just how it is." (Male participant)

It is interesting that even though these participants feel that all workers are treated equally irrespective of gender, they agree that the weight of expectations to succeed is far greater on a female worker than a male worker.

Results further suggest that males and females both feel that mentorship is important for their success, and that the gender of a mentor is unimportant. Many male participants shared their stories about being mentored by females at the workplace and in college. Similarly, female participants felt that as long as there is a mentor to guide them, it does not matter if it is a male or a female. Participants stated:

"I don't see a problem with it at all." (Female participant)

"I have no quarrels with gender." (Male participant)

The participants all experienced some level of mentorship at different stages from both male and female mentors.

5. DISCUSSION

Women make up only 20% of the cybersecurity workforce, which is up from 11% in 2013, (Richter, 2019) but still needs to be better in terms of involving more women in the field. There is lot of demand in the cybersecurity field

and the lack of women in IT overall and cybersecurity in particular, has created a gap in diversity that fails to capture women's perspectives. Lack of female participation in cybersecurity programs and careers is a broad-spectrum systemic problem that needs to be addressed.

The results of this study identify perceptions of cybersecurity students about challenges and the role of mentorship for cybersecurity careers. It is important to note that the results from this qualitative study are limited by the small population of participants and that the goal of this research is not to provide a generalized set of results for all cybersecurity students, but rather to gain a clearer understanding of the experiences and opinions of this group of participants in order to contribute to the overall understanding of the underlying issues. The themes suggest an awareness of women facing different expectations in general and are conscious about the differences. However, these results also show a generation of young students not much worried about typical stereotypes but expecting competency and skills as the main drivers of success.

A broader and inclusive approach may be required to address this gender gap. Frieze and Quesenberry (2019) in a case study about representation of women in computer science majors, concluded that cultural factors are more important than gender differences as an approach in understanding and fixing this problem. Creating a culture in an academic institution where women feel they have opportunities to pursue things that interest them in an amicable environment requires institutional support at many levels. A cultural approach considers the existing stereotypes and provides funding, opportunities, and guidance for women. There are strong women in the cybersecurity space already who need to be positioned in a way that their voices are heard. A female working as a cybersecurity leader can intentionally act as role model for a younger generation of girls (Gonzalez, 2015).

Recommendations

Based on the data and research literature in the field, the following recommendations are presented. These are prescriptive strategies that are grounded in the data-driven themes and provide guidance to practitioners and academic audiences for solutions to this problem.

Challenges were identified as a constant need to learn to keep up with the challenges of a rapidly changing field, the challenging nature of the field that holds a high level of responsibility, and the perception that the field is male-dominated. Recommendations to address these challenges include:

- Provide constant learning opportunities for employees; e.g., training, conferences, seminars, formal education
- Consider job rotation for exposure to new methods and tools
- Promote teamwork and collaboration in order to alleviate some of the pressure in responsibility for individual cybersecurity professionals
- Highlight women in cybersecurity leadership positions inside and outside the organization
- Challenge stereotypes about cybersecurity jobs through reach-out programs for women and girls in the K-12 system

Perceptions about the role of mentorship were identified as the influence of peers, professors and teachers, family and friends, and cybersecurity-focused student clubs. Recommendations to address these perceptions and reinforce the mentorship roles seen as valuable by participants include:

- Create a positive environment for students to reach out and collaborate; Peers have a significant role in mentoring and promoting co-workers
- Provide opportunities for professors to become formal or informal mentors for students in cybersecurity
- Promote cybersecurity-focused organizations that allow students to interact with industry experts to provide context for learning
- Recognize that family and friends play an important role in influencing educational and career choices; Educate and interact with families of potential students

Mentors are important to both men and women who are starting out in the cybersecurity field. Mentors offer invaluable guidance on job decisions, degrees, and other specializations in the industry ("Mentorship", 2018). The relationship between mentor and mentee is one of mutual benefits. Mentors can learn from their mentees in terms of new applications and tools in the rapidly changing cybersecurity industry. There is also shortage of mentors to provide training and mentorship to young women, something that is essential for women to be attracted to the field (Gonzalez, 2015). It is crucial that the government continues to support STEM education through funds that are used to

train and develop mentorship programs. It is important to get young girls excited about cybersecurity in high school (Dampier, Kelly, & Carr, 2012) and for students to be mentored not only by faculty members but also by peers. The researcher's university has successfully created a Leadership and Mentorship program for women that provides great opportunities for mentorship by professors, industry experts, and peers. It also provides opportunities for the women in the program to mentor the freshmen cohort, as soon as they are juniors in their programs. It could be beneficial for programs like these to be focused specifically on the cybersecurity field.

Finally, differences between men and women regarding challenges for cybersecurity careers and the role of mentorship were explored. The findings indicate that gender is not an issue for job tasks, though there is more pressure on women to show confidence in the workplace. Findings also indicate that gender is unimportant for mentorship. Recommendations to address these findings include:

- Recognize that female employees have greater pressure to perform well and succeed in the workplace; Discuss gender expectations in the work environment openly for constructive dialogue
- Recognize that mentorship is a symbiotic process with mutual give and take, but gender of the mentor does not matter
- Refrain from special treatment for women to encourage participation, but rather promote a culture of equal opportunities; This will go a long way in correcting gender imbalance

6. CONCLUSION

There are many contributions of this study. It is a unique study about the perceptions of cybersecurity students regarding challenges in pursuing a career in their field and the role of mentorship in success in this field. The results contribute to the body of knowledge by providing insight into gender differences in the cybersecurity field as this is a relatively less explored area in research. These results can fuel several studies in this area.

Two results stood out to the researchers about the findings of this study. The first is that although there is a clearly identified gender gap in the field of cybersecurity, the participants in this study displayed an interesting mix of perceptions on this issue. They indicated that a challenge exists for women in that the field of cybersecurity is perceived as a male-dominated field, and noted that their experiences also show that women need to show a higher level of confidence than their male counterparts in their day-to-day activities in order to be successful. These findings were consistent with previous research (Richter, 2019; Morgan, 2019; Higgins, 2018; Willis-Ford, 2018; D'Hondt, 2016). However, the participants, citing their own experiences via internships in the workplace, were also very clear that males and females were not treated differently in terms of job tasks, and that gender was not an issue in terms of team or management roles. There were no differing viewpoints on this issue between male and female participants in the study. This potentially speaks to a promising future as this new cohort of students completes college and moves into the workplace carrying less gender stereotypes and expectations of bias and more confidence that their own competency and skills will be the primary drivers of their success in the profession.

The second finding is in regard to the role of mentorship. Participants found mentorship to be valuable, which is consistent with the literature ("Mentorship", 2018; Frost & Sullivan, 2017; D'Hondt, 2016). However, they surprisingly cited peer mentorship as one of the driving forces in their success within their cybersecurity programs. This was recognized through informal peer relationships during classes at the university combined with the influence of a cybersecurity-focused student club that exposed students to a variety of industry experts, sites, and areas of research.

The main limitation of the study is that all participants are from the same university. More studies are needed that incorporate participants from multiple schools and other populations. Despite this limitation, this study contributes to practitioners in industry as well as academic administrators by recommending strategies to overcome the challenges identified and formalize mentorship initiatives.

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Collaborative Course Design of Entrepreneurship Projects in a College of Computer Science and Information Systems

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Abstract

Colleges are engaging students in collaborative design courses on diverse projects. More of the courses could be focusing on cross-disciplinary entrepreneurship projects including computer science and information systems students with other disciplinary students. The authors of this paper describe a course that is focusing on collaborative design and cross-disciplinary entrepreneurship on innovation projects by students as members of self-directed teams. The course is involving the students on crowdfunding projects of product prototyping, from which they are learning a marketable repertoire of skills. The findings of this paper will be beneficial to educators in colleges of computer science and information systems considering enriching pedagogical practices to be contemporary with the demands of industry.

Keywords: collaborative learning, cooperative learning, design factory, entrepreneurship, experiential learning, information systems curriculum, self-directed teams, problem-based learning, project-based learning

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1. BACKGROUND

Active collaborative learning is an alternative concept of directly engaging students in the content of courses, instead of having students listening to lectures (Felder & Brent, 2016a). Engagement consists of divergent exercises for fostering deep learning of the material of the courses (Wang, Su, Cheung, Wong & Kwong, 2014). Engagement in colleges of computer science and information systems could consist especially of active interactions for cooperative learning (Johnson, Johnson & Smith, 2016) with other cross-disciplinary students. Knowledge from courses is consistently enhanced in group learning practices on projects indicated in the literature (Prince, 2004). Active collaborative learning is clearly an approach for increased learning of students.

Concurrently, courses in entrepreneurship are developing as an area of curricula for applying collaborative group learning. Entrepreneurship is already an example of collaborative design experiential learning practices (Noyes, 2018), in including students on projects. Entrepreneurship in colleges of information systems could involve students actively on high-potential projects as members of passionate teams (Byers, Dorf & Nelson, 2011). Focus of learning is not from lectures but from forms of problem-based learning (Barrett & Moore, 2011) and project-based learning (Prince & Felder, 2007) of the students on teams. Collaborative learning and entrepreneurship are approaches

equivalently for further increased learning of students.

Not enough colleges of computer science and information systems are however including diverse approaches of learning such as active collaborative learning in courses such as entrepreneurship (Schrage, 2018). Lectures are indicated to be frequent knowledge methods inappropriate for the learning of marketable skills (Stains, Harshman, Barker, Chasteen, Cole, DeChenne-Peters & Young, 2018). Marketability of students is formed more from collaborative problem-based learning and project-based learning practices that are inherently industry practices. Marketability is found further from performances of these practices as skills on spirited student teams (Magana, Seah & Thomas, 2018). Therefore, this paper introduces a course, beyond basic current entrepreneurship syllabi, for engaging students in active collaborative design learning on entrepreneurship projects in a school of computer science and information systems.

2. INTRODUCTION

The course in this paper is *Collaborative Design Innovation*, begun in winter / spring 2019 in the Seidenberg School of Computer Science and Information Systems of Pace University. The course is an active learning experience for students in cooperatively exploring entrepreneurial products as members of project self-directed teams (Sears & Pai, 2012). The dimensions of the experiences are formed from cooperative learning (Connolly & Rush, 2018) and experiential learning (Noyes, 2018) and problem-based and project-based learning, as depicted in Figure 1 of the Appendix. The experiences are formulated further from a "design factory" experimental learning platform for interdisciplinary inventions (Ekman, 2018). The instructor, the second author of this paper, functions as a facilitator, not as a lecturer, to the students (Guthrie, 2010). The students function as the intended participants on the projects of their teams.

The learning objectives of the 3-credit course of 14 3-hour sessions are below:

- Experience challenges of collaborative dynamics in designs of big idea entrepreneurship projects, as members of self-directed teams;
- Experience design methods on ideation processes of product storyboarding and product prototyping projects, as students and as student teams;
- Experience and learn improved marketable skills, including collaboration, communication, creative thinking, critical thinking, diversity, empathy, entrepreneurship, flexibility, management and problem solving, from interactions with cross-disciplinary students on the projects;
- Experience new industry opportunities and perspectives on the entrepreneurship projects and the potential solutions, as students and as student teams; and
- Experience crowdfunding entrepreneurship pitch presentations of functional product prototyping solutions, as students and as student teams.

The course is a diverse experience inclusive of computer science and information systems students and interdisciplinary liberal arts and business students, for increased learning of the computer science and information systems students of other perspectives of students not in the Seidenberg School.

The learning plan of the course is conceptualized below for the 14 semester sessions:

Orientation

(Weeks 1 -2)

- Challenges and Fears
- Collaborative Culture for Design Entrepreneurial Mind and Process
- Expectations and Experiences on Design Projects and Factors for Innovation Projects
- Design Factory Methodology
- Potential of Interdisciplinary Teams on Innovation Projects

Organization

(Weeks 3-4)

- Expectations of Industry on Big Idea Projects
- Funding Perspectives on Big Idea ("Blue Sky") Projects
- Gathering Perspectives on Big Idea (Products) Projects

- Gathering and Learning (Products) Requirements
- Parameters of Projects (from Professor)

Process

(Weeks 5 -12)

- Brainstorming (Brainwalking) on Big Idea (Products) Projects
- Storyboarding Big Idea (Products) Projects Scenarios
- Prototyping Big Idea (Products) Projects Simulations
- Prototyping Big Idea (Products) Projects (Features) Specifications
- Prototyping Big Idea (Products) Projects Prototypes in Stages

- Product Development Process
- Rapid Application Development (RAD) and Iteration Steps

- Pitch Presentation Standards (from Professor)

Production

(Weeks 13 -14)

- Final Big Idea (Product) Projects Prototypes
- Gala Pitch Presentations of Big Idea (Products) Projects Prototypes

The syllabus of *Collaborative Design Innovation* is detailed further, with deliverables, exercises and films, and sub-topics and treks of the weeks, in Table 1 of the Appendix, with customization feasible to other information systems and business syllabi.

The course in winter / spring 2019 consisted of n=5 distinct entrepreneurship organizations or projects, decided by members of n=5 incubating self-directed teams of mostly n=5 members a team, in a class of n=27 in total. The instructor decided deliberatively on the members of the teams, in order to ensure diversity as feasible by demographics, discipline, gender and student year on the teams (Weimer, 2018), but members had the option to transfer to one other team by the end of the second class session, though none transferred. The characteristics of the students by demographics are below:

- 3 African-Americans
- 15 American Caucasians
- 5 Asian-Americans
- 1 European International
- 3 Hispanic-Americans

The disciplines of the students are below:

- 14 Seidenberg School of Computer Science and Information Systems
- 7 Liberal Arts, Health and Humanities*
- 6 Lubin School of Business

*multiple schools of Pace University

The genders of the students are as follows:

- 7 Female
- 20 Male

The student years are as follows:

- 12 Freshman
- 7 Sophomore
- 4 Junior
- 4 Senior

From instructor parameters of a rapid application development process (RAD), the members of the teams explored authentic consensus learning projects (Bell, 2010). The projects involved a collaborative design innovation laboratory, a dance entertainment exchange system, a disposable i-phone charger system, an e-cigarette filtration system, and a firearm detection school system zone, for hypothetical organizations, though the students postured as owners. From the projects, they initiated their own learning in the semester (Helle, Tynjala, Olkinvora & Lonka, 2007). They functioned as 1 group in classroom sessions and as 5 teams in "creative spaces" (Baidawi, 2018) of the Seidenberg School. The implementation of the projects in prototyping solutions was the responsibility of the teams.

The instructor helped the members of the teams in learning the design factory learning platform (Ekman, 2018). Importantly, the instructor helped as a mentor the student teams in the classroom sessions, in the School spaces, and on the Discussion Board of the Academic Blackboard e-Education Suite. He included materials (e.g., flipcharts, markers and post-its) if needed by the student teams.

From luncheons, mini-presentations of the teams, and notably reflection reports and research studies of those on the teams – "hooks" (Reynolds & Kearns, 2017), as in Table 1, the professor monitored the progress of the projects of the teams without intruding on the

responsibilities of the teams. He motivated them with exercises and games, external labs and movies and "Escape the Room" (Groupon), "Let's Talk Relieving Stress" and "WeWork" Workspace treks in the semester. Moreover, he motivated them with interactions with entrepreneurship mentor firms and equity investor firms as alternate available face-to-face sources (Magana, Seah & Thomas, 2018), also as in Table 1.

At the end of the 14th session, the product prototyping solutions were presented as pitch presentations or final reports (Thompson & Beak, 2007) as if to venture capitalists. The instructor graded 50% for member performance and 50% for performance as a team. As an option, students graded themselves as input to the instructor.

Finally, for books of *Collaborative Design Innovation*, the instructor included Kelley & Kelley, Creative Confidence: Unleashing the Creative Potential Within Us All and Bjorklund, T.A., et.al., Passion-Based Co-Creation, both for the reference; and for publications, Entrepreneur for practitioner study and the Journal of Innovation and Entrepreneurship and the Journal of Social Entrepreneurship for scholarly study.

3. FOCUS OF PAPER

The benefits of the course as an authentic learning experience are the focus of this paper.

Courses in designing entrepreneurship projects as if the projects are done in industry are considered excellent for executive function skills (DiTullio, 2018). Courses consisting of project-based learning on entrepreneurship are considered as encouraging improved marketable skills of students (Gol & Nafalski, 2007). Firms in industry desire information systems students to function in organizations as problem solvers (Schwering, 2015) by having as team players a heterogeneity of skills beyond skills in technology (Ambrosio, 2018), a justification for the *Collaborative Design Innovation* syllabus. Factors of learning outcomes are focused on perceptions of a repertoire of skills found from the literature (Bjorklund, et.al., 2017, Gedeon & Valliere, 2018 & Felder & Brent, 2016b) and are integrated for this paper:

- Collaboration (Bjorklund, et.al., 2017) – factor from which students perceived improved fruitful engagement skills with other students;
- Communication (Gedeon & Valliere, 2018) – factor from which the students perceived increased interaction and listening skills with other students;
- Creative Thinking (Felder & Brent, 2016b) – factor from which students perceived increased experimental and imaginative ideation skills with other students on their teams;
- Critical Thinking (Felder & Brent, 2016b & Gedeon & Valliere, 2018) – factor from which the students perceived increased interpretative logical skills with other students;
- Diversity (Bjorklund, et.al,, 2017 & Felder & Brent, 2016b) – factor from which students perceived increased cross-cultural interdisciplinary skills with other peer students;
- Empathy (Bjorklund, et.al., 2017) – factor from which the students perceived increased inter-personal sensitivity skills with other peer students on their teams;
- Entrepreneurship (Bjorklund, et.al., 2017 & Gedeon & Valliere, 2018) – factor from which students perceived increased improvised innovation skills with other students and persuasion skills on their teams;
- Flexibility (Gedeon & Valliere, 2018) – factor from which the students perceived increased group negotiation and perspective skills, notably in stressful situations with other students;
- Management (Gedeon & Valliere, 2018) – factor from which students perceived increased organizational and personal planning skills, such as time management, with other students on their teams; and
- Problem Solving (Bjorklund, et.al., 2017 & Felder & Brent, 2016b) – factor from which the students perceived increased optimal resolution skills with other students on their teams.

The benefits of *Collaborative Design Innovation* in addressing an alternative to non-collaborative learning in winter / spring 2019 may be from evaluation of the above factors, which will be beneficial to instructors considering enriching

pedagogical practices to be current with the goals of industry.

4. METHODOLOGY OF PAPER

The methodology of this paper evaluated the perceptions of the students in the *Collaborative Design Innovation* course in the Seidenberg School of Computer Science and Information Systems of Pace University.

The perceptions pf the n=27 undergraduate students were evaluated from the aforementioned n=10 factors of skills, defined by the instructor for the students. Following the pitch presentations at the end of the semester in spring 2019, the students furnished their perceptions of progression anonymously and quantitatively on a pre-tested Likert-like instrument, rating their learned or non-learned skills, from the aforementioned definitions of the skills, from a very high (5) impact to a very low (1) impact or zero (0) scaling on their skills. Moreover, the students furnished perceptions of their progression non-quantitatively and separately in their mid-term and final reflection reports of the semester.

The interpretation of the statistics was fulfilled from Microsoft EXCEL 2016 16.0 and IBM Statistics 24 (Adams & Lawrence, 2019), for the findings in the next section of this study.

5. ANALYSIS AND DISCUSSION OF FINDINGS

The analysis of the evaluations is disclosing favorable impacts (means=4.17 /5.00) from the overall perceptions of the n=27 students. Evaluations of the n=27 students are highlighting favorable ratings from collaboration (4.33) to problem solving (4.48) skills. Evaluations of the perceptions of the n=14 computer science and information systems students of the learning process are especially highlighting favorable ratings from collaboration (4.14), communication (3.86), creative thinking (4.50), critical thinking (4.36), diversity (4.71), empathy (3.36), entrepreneurship (4.29), flexibility (3.93), management (4.07) and problem solving (4.43). Such evaluations are from interactions on the projects of the n=5 small groups as an apparent ideal number on small teams (Bean, 2011) involving the novelty of liberal arts and business students on the teams (Matsudaira, 2018). As to the n=13 liberal arts and business students, evaluations are indicating favorable learning ratings from collaboration (4.67 and 4.50) to problem solving (4.43 and 4.67) skills.

Evaluations of these perceptions of the students are descriptively documented in Tables 2A (all students) and 2B (computer science and information systems, business and liberal arts students) of the Appendix.

Evaluations of freshmen (4.27), sophomore (3.93), junior (3.93) and senior (4.50) students individually are indicating overall favorable ratings.

Evaluations of the students by years are documented in Tables 3A (freshmen students) and 3B (sophomore, junior and senior students).

Findings are further highlighting favorable ratings behind these perceptions from collaboration (4.18) to problem solving (4.45) design skills from computer science and information systems students that were not in previous semesters on small teams. Previously such students were on individualized projects without interactions with other non-computer science and non-information systems students. Other findings from collaboration (4.71) to problem solving (4.57) factors from overall liberal arts and business students not previously on self-directed small teams are highlighting an equivalent favorable snapshot, and such students will be experienced now and favorably if not hopefully inclined to be on projects on small teams in future semesters.

The benefits of active authentic learning are evident from the findings. Collaboration (4.33) and communication (4.04) of all students in Table 2A are effectively facilitating big idea breakthroughs in the brainstorming to the prototyping and of the students, as they are first focusing on gaining insights on the problems of the projects, not the answers but the questions (Gregersen, 2018). In fact, contracts developed by each of the students for outcomes of the projects are identifying their responsibilities on their teams (Landfair, 2018), improving communication and collaboration of the students.

Though discomforting at first, diversity (4.33) and empathy (3.22) of all students in Table 2A are indicating contributing factors in emotional intelligence (Salovey & Mayer, 1990), in the formation of the projects and in the results by empathizing demographic, gender and, importantly, interdisciplinary students, as members of their teams (Tappert, Leider & Li,

2019), which as an example in the humanities of liberal arts included dance studio students not known normally to information systems students.

Entrepreneurship (4.56) of all students in Table 2A is also indicating freedom in ingenuity in inventive opportunities in the solutions of these students.

Factors of flexibility (3.93) and management (4.00) are impacts in the learning of organizational and perceptual skills, notably as the projects stressed the students. Increased learning of creative thinking (4.52) to learning of critical skeptical thinking (4.33) of all students in Table 2A as members of teams (Bean, 2011) is indicating informed ingredients in the project solutions of the students. Participant problem solving (4.48) in pursuing the prototyping solutions and visualizations (Roam, 2008) as members of teams, not as " lonely riders", is indicating in Table 2A the importance of the learning and of sharing for all of the students (Park & Choi, 2014). These findings from the cooperative process of problem-based and project-based learning are indicating the gradual learning of an optimal repertoire of skills (Bell, 2010) by all of the n=27 students and notably by the n=14 computer science and information systems students, a justification for *Collaborative Design Innovation* to be offered in multiple semesters.

Finally, findings of correlations and frequency distributions of the perception ratings of the students are documented in Table 4 and Table 5.

6. IMPLICATIONS FOR PRACTICE

The findings found in this paper are highlighting the benefits of a collaborative design course for computer science and information systems students. These students are dialogically interconnecting with liberal arts and business students, with whom without the course they might not be interacting to do the projects (Barnes, 2019). They are cooperatively learning and are open and patient to other demographic and gender perspectives of the business and the liberal arts students not similar to theirs, in order to produce project results. The problem-based and project-based learning is driving the solutions of the students (McKay, 2018). The implication for computer science and information systems instructors is that for appropriate courses, and as feasible, students will benefit from a course designed for involving non-computer science and non-information systems students.

The findings are further highlighting the benefits of disruptive and non-disruptive interdisciplinary projects for computer science and information systems students. They are identifying innovation opportunities for project solutions and visualizations (Roam, 2008) from a learning process of brainstorming, storyboarding and prototyping that is akin to industry practices (Kim & Mauborgne, 2019). The implication for computer science and information systems instructors is that their students will benefit from a course designed for inclusion of industry innovation practices on projects.

The computer science and information systems students in the course are indicating that they are learning in-demand skills. The gap in industry skills is not necessarily in hard skills but in persuasive "soft skills" (Davis, 2018) such as from the collaboration to problem solving skills they are learning on the projects. The gap is generally notable on other project teams in the Seidenberg School, but in the course the students are helping other students (Tamer, 2018), learning the soft skills to be team players and recognizing the skills in other students. Schools of information systems are not often providing such skilled students. The importance for computer science and information systems instructors is that their students will benefit from courses informed by industry requirements for skills beyond mere technologies.

The findings are indicating the instructor is functioning not as a lecturer but as a mentor to the students, implying initially less instructor involvement on a problem-based or project-based learning program, which could be a downside for other instructors. However, the instructor in winter / spring 2019 found as in the literature (Miller, 2018) a lot more involvement as a mentor and a motivator on the projects, so that the students were fully functioning gradually but productively on their self-directed spirited teams. The importance for instructors is that a project-based learning syllabus will inevitably necessitate more involvement and motivation one-on-one with students, especially students not previously on self-directed teams.

Lastly, the findings of this paper are indicating that group projects are initially an issue for mostly students not previously on self-directed teams. As novices they have to be helped in learning the importance of interdependence of fellow members of their teams, from the

instructor and from the students previously on teams. The interdependence of the information systems or non-information systems students is a prerequisite on the project-based learning tasks of teams (Knutson, 2018). The productivity of the students is influenced prominently if they opt in spiritedly on the tasks of their teams. The final implication for instructors is that the requirements for self-directed teams will necessitate more involvement of not only the instructor as a mentor but also of the students themselves.

7. LIMITATIONS AND OPPORTUNITIES

The findings from the course on Collaborative Design Innovation during the duration of only winter / spring 2019, with a limited number of students, are limitations of this paper. Further limitations include hypothetical imagined organizations for the pseudo projects invented by the student teams. Future paper replication will include more non-pseudo organizational projects, involving more computer science and information systems students partnered with more non-computer science and non-information systems students, as a sample over a period of semesters.

8. CONCLUSION

Collaborative design courses are engaging computer science and information systems students on cross-disciplinary projects. Students are engaging on innovation projects in interdisciplinary self-directed teams, learning divergent points of view. In Collaborative Design Innovation computer science and information systems students are engaging in a learning process with liberal arts, humanities and business students on the teams. In the perceptions of the students, they are learning a marketable repertoire of skills, notably in the responses of the students not previously on teams. Importantly, the computer science and information systems students in this paper are learning to be more than technologists, a finding of significance as such students may be limited as mere niche technologists without Collaborative Design Innovation. This paper informs instructors in the learning process involving all of the students in this study on the self-directed teams. Furthermore, this paper informs instructors on the integral mentoring process involving computer science and information systems professors as motivators of the student teams. In conclusion, the findings of this paper will hopefully inspire instructors in schools of computer science and information systems to integrate the pedagogical practices introduced in this study.

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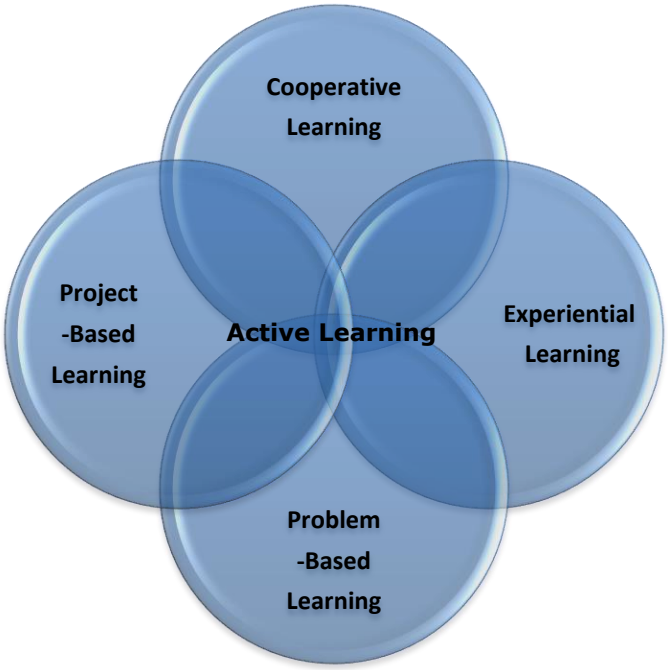
APPENDIX



Active Authentic Design Learning
Figure 1: Concept of Course – *Design Innovation and Thinking* –Seidenberg School of Computer Science and Information Systems

Table 1: Course Outline – *Design Innovation and Thinking* –Seidenberg School of Computer Science and Information Systems

Semester Weeks	Topics of the Weeks	Treks of the Weeks (Optional)
1	**Orientation** Challenges and Fears - Acquaintance Exercise Collaborative Culture for Design Entrepreneurial Mind and Process - Entrepreneurship Exercise Expectations and Experiences on Design Projects Factors for Innovation Projects Deliverable: *Preliminary Course Reflection Report* (by Student)	
2	**Orientation** Design Factory Methodology - Passion-Driven Processes for Innovation Projects Potential of Inter-Disciplinary Teams on Innovation Projects - Movie: The Purple Heart (Amazon) - Professor Role and Roles of Students Self-Directed Teams	Design Factory Lab (of Aalto University) in Seidenberg School

3	**Organization** Collaboration and Diversity Exercise on Problem Solving Formation of Student Teams (Member Selections by Professor) - Interdependencies of Member Students on Teams Gathering Preliminary Perspectives on Big Ideas (Products) Projects - Marketplace Product Rationales Gathering and Learning Preliminary Requirements – Stage 1 Parameters of Projects (from Professor) Deliverable: *Preliminary Contracts* (Tasks) *of Member Students on Teams* (by Student)	Escape the Room (Groupon)
4	**Organization** Gathering Final Perspectives on Big Ideas (Products) Projects Gathering and Learning Requirements – Stage 2 Deliverables: *Mini-Presentations on Preliminary Big Ideas (Products) Projects* (by Team) - *10 Second Pitch Presentations* *Entrepreneur Practitioner Research Study (by Student)*	Lubin School of Business Entrepreneurship Lab
5	**Process** Brainstorming Exercise: Commute by Wheelchair Brainstorming on Big Ideas (Products) Projects - Customer Differentiation - Differentiation of New Products - Ideas vs. Opportunities of Products Product Development Process Movie: Steve Jobs	
6	**Process** Brainstorming on Big Ideas (Products) Projects Product Development Process	Advisory Board Entrepreneurship Mentor Firm
7	**Process** Brainstorming on Final Big Ideas (Products) Projects Product Development Process Preliminary Big Ideas (Products) Projects (Scenarios)	

	Storyboarding Deliverables: *Celebratory Brainstorming on Final Big Ideas (Products) Projects Breakfast* (by Class) *Final Contracts* (Tasks) *of Member Students on Teams* (by Student) *Mini-Presentations on Final Big Ideas (Products) Projects* (by Team)	
8	**Process** Big Ideas (Products) Projects (Scenarios) Storyboarding Product Development Process Deliverable: *Journal of Innovation and Entrepreneurship Scholarly Study* (by Student)	WeWork (Workspace)
9	**Process** Final Big Ideas (Products) Projects (Scenarios) Storyboarding Preliminary Product Prototyping (Simulations) - Product Prototype (Features) Specifications Product Development Process Rapid Application Development (RAD) Steps Deliverables: *Celebratory Big Ideas (Products) Projects (Scenarios) Storyboarding Luncheon* (by Class) *Half-Gala Pitch Presentations on Final Big Ideas (Products) Projects (Scenarios) Storyboarding* (by Team)	Advisory Board Entrepreneurship Mentor Firm
10	**Process** Movie: The Dropout – Scam in Silicon Valley (Netflix) Product Development Process Product Prototyping (Simulations) - Product Prototype (Features) Specifications Prototyping the Prototype – Stage 1 Rapid Application Development (RAD) and Iteration Steps	Application (App) Development Lab in Seidenberg School
11	**Process** Product Development Process Product Prototyping (Simulations) - Product Prototype (Features) Specifications Prototyping the Prototype – Stage 2 Rapid Application Development (RAD) and Iteration Steps	WeWork (Workspace)

	Deliverable: *Mini-Presentations on Interim Product Prototyping (Simulations)* (by Team)	
12	**Process** Final Product Prototyping (Simulations) Pitch Presentation Standards Product Development Process Rapid Application Development (RAD) Steps Deliverable: *MIT Technology Review Practitioner Research Study* (by Student)	Equity Investor Firm
13	**Production** Final Product Prototyping (Simulations) - Financial Funding Plan for Resources - Member Propositions of Teams - Rewards and Risks of Support Rapid Application Development (RAD) Steps Deliverable: *Preliminary Gala Pitch Presentations of Product Prototypes* (by Team)	Advisory Board Start-Up Venture
14	**Production** Deliverables: *Gala Pitch Presentations of Product Prototypes (by Team)* - *Product Project Prototype Walkthroughs (by Team)* *Celebratory Gala Pitch Presentations Dinner* (by Class) *with Dean of Seidenberg School of Computer Science and Information Systems* *Final Project Reflection Reports* (by Student) *Recognitions of Students and Teams* (by Professor)	

Note: Projects are performed by student teams beginning in Organization Week 3.
Note 1: Prototypes may be electronic or paper prototyping simulations.

Table 2A: Course – *Design Innovation and Thinking* – Factor Perceptions of All Students by Discipline Summary – Winter / Spring 2019

	All Students	
	n=27	
	Mean	Standard Deviation
Factors (Skills)		
Collaboration	4.33	1.18
Communication	4.04	1.13
Creative Thinking	4.52	0.80
Critical Thinking	4.33	0.88
Diversity	4.33	0.96
Empathy	3.22	1.65
Entrepreneurship	4.56	0.85
Flexibility	3.93	1.11
Management	4.00	1.11
Problem Solving	4.48	0.85
	4.17	1.13

Legend of Rating Scaling: (5) – Very High Impact [from Perceptions of Learned Skills], (4) High Impact, (3) Intermediate Impact, (2) Low Impact, (1) Very Low Impact, and (0) No Impact

Table 2B: Course – *Design Innovation and Thinking* – Factor Perceptions of Students by Discipline Summary – Winter / Spring 2019

	Computer Science and Information Systems Students		Business Students		Liberal Arts Students	
	n=14		n=6		n=7	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Factors (Skills)						
Collaboration	4.14	1.46	4.50	0.84	4.67	0.58
Communication	3.86	1.41	4.50	0.84	4.33	0.58
Creative Thinking	4.50	0.76	4.67	0.82	4.33	1.15
Critical Thinking	4.36	0.84	4.33	1.03	4.29	0.95
Diversity	4.71	0.73	4.00	1.10	3.86	1.07
Empathy	3.36	1.78	3.17	1.83	3.00	1.41
Entrepreneurship	4.29	0.99	5.00	0.00	4.71	0.76
Flexibility	3.93	1.21	4.33	1.03	3.57	0.98
Management	4.07	1.21	4.33	1.03	3.57	0.98
Problem Solving	4.43	0.94	4.67	0.82	4.43	0.79
	4.16	1.20	4.35	1.05	4.04	1.03

Table 3A: Course – *Design Innovation and Thinking* – Factor Perceptions of Students by Year – Winter / Spring 2019

	Freshman Students	
	n=12	
	Mean	Standard Deviation
Factors (Skills)		
Collaboration	4.25	1.48
Communication	4.17	1.47
Creative Thinking	4.58	0.79
Critical Thinking	4.33	0.89
Diversity	4.67	0.78
Empathy	3.00	1.91
Entrepreneurship	4.67	0.78
Flexibility	4.08	1.00
Management	4.33	0.89
Problem Solving	4.58	0.79
	4.27	1.19

Table 3B: Course – *Design Innovation and Thinking* – Factor Perceptions of Students by Year – Winter / Spring 2019

	Sophomore Students		Junior Students		Senior Students	
	n=7		n=4		n=4	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Factors (Skills)						
Collaboration	4.43	0.98	4.25	0.96	4.50	1.00
Communication	3.71	0.76	3.75	0.50	4.50	1.00
Creative Thinking	4.00	1.00	5.00	0.00	4.75	0.50
Critical Thinking	3.86	1.07	4.75	0.50	4.75	0.50
Diversity	4.43	0.98	3.50	1.00	4.00	1.15
Empathy	3.43	1.62	2.75	1.50	4.00	1.15
Entrepreneurship	4.43	0.98	4.50	1.00	4.50	1.00
Flexibility	3.43	1.40	3.75	0.96	4.50	1.00
Management	3.57	1.51	3.25	0.50	4.50	1.00
Problem Solving	4.43	0.98	3.75	0.96	5.00	0.00
	3.93	1.15	3.93	1.02	4.50	0.85

Table 4: Course – *Design Innovation and Thinking* – Spearman Correlations of Paper – All Students - Winter / Spring 2019

	Collaboration	Communication	Creative Thinking	Critical Thinking	Diversity
Communication	0.4793**				
Creative Thinking	-0.0055	0.0998			
Critical Thinking	0.1128	0.2547	0.6822*		
Diversity	-0.1873	-0.0482	-0.1256	-0.0976	
Empathy	0.2460	0.3522	0.0936	0.2022	0.1507
Entrepreneurship	0.2672	0.7353*	0.0855	0.1757	-0.1890
Flexibility	0.6876*	0.6986*	0.1924	0.3321	-0.1043
Management	0.4941*	0.557*	0.3440	0.2995	-0.0551

	Diversity	Empathy	Entrepreneurship	Flexibility	Management
Creative Thinking					
Critical Thinking					
Diversity					
Empathy					
Entrepreneurship		0.2592			
Flexibility		0.5399*	0.5104*		
Management		0.4337**	0.3687	0.6175*	
Problem Solving		-0.1037	0.0714	0.0919	0.3608

Level of Significance = 0.05, with * Signifying a Probability Value Equal or Less Than 0.01 and with ** Signifying a Probability Value Between Greater Than 0.01 But Less Than 0.05

Table 5: Course – *Design Innovation and Thinking* – Frequency Distributions of Paper – All Students - Winter / Spring 2019

	Collaboration	Communication	Creative Thinking	Critical Thinking	Diversity
Rating Scaling					
(5) Very High Impact	66.7%	40.8%	70.4%	59.3%	66.7%
(4) High Impact	11.1%	33.3%	11.1%	14.8%	-
(3) Intermediate Impact	18.5%	22.2%	18.5%	25.9%	33.3%
(2) Low Impact	-	-	-	-	-
(1) No Impact or Blank	3.7%	3.7%	-	-	-

	Empathy	Entrepreneurship	Flexibility	Management	Problem Solving
Rating Scaling					
(5) Very High Impact	33.4%	77.8%	44.5%	48.2%	70.4%
(4) High Impact	11.1%	-	11.1%	11.1%	7.4%
(3) Intermediate Impact	25.9%	22.2%	40.7%	37.0%	22.2%
(2) Low Impact	11.1%	-	-	-	-
(1) No Impact or Blank	18.5%	-	3.7%	3.7%	-

Using an Ocean Shipping Game to Teach Transportation Fundamentals to Supply Chain Management Students

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Abstract

This article illustrates the benefits of off the shelf simulation software to increase learning for students in the classroom. Furthermore, the use of a computer game presents a unique opportunity for increased understanding of transportation fundamentals in a fun environment. Another benefit is that the use of the simulation helps Millennial learners to gain understanding beyond a basic lecture type environment by experiencing the problems, opportunities and solutions sets applied in a realistic transportation simulation. The overall effect is students appear to retain more about specific business practices through a game experience when compared to lecture formats of the same concepts. Finally, the paper demonstrates how to better position the simulation beyond just the game mechanics to ensure the students are learning key transportation fundamentals and overall business practices.

Keywords: simulation, learning, transportation, edutainment, supply chain management.

1. INTRODUCTION

As Generation Y and Z (Millennials) move through our education system, the nature of instruction continues to evolve with them. A key question that many educators face is the best method to convey critical learning objectives to the typical Millennial student in a format that will increase learning retention, understanding, and application of various core competencies.

A good example of the challenges of teaching these types of items comes from the Supply Chain Management (SCM) major. SCM students must grasp and apply large amounts of diverse learning across various business functions (i.e., operations, logistics, transportation, purchasing, etc.) The sheer volume of material lends itself to the tradition lecture format. However, this may not provide the best learning outcomes for the student or program.

This article presents an example of using a transportation computer game or simulation to supplement the basic lecture process of teaching critical SCM tools to senior level students. The simulation used provides an excellent tool to both introduce key fundamental concepts and to implement a fun, individualized, self-paced method. The SCM major learns the key concepts through experienced-based learning

that can then be discussed in the classroom as opposed to the traditional lecture format.

After this introduction, a brief literature review highlights the importance of Millennial learning and the value of non-lecture based formats. Also, it discusses similar uses of transportation simulations as learning devices both in and out of the classroom and with various learning audiences. Next, the article discusses the application of the transportation simulation (Ports of Call) with the course to maximize its effectiveness. Finally, the article concludes with some general findings along with a discussion of future opportunities for application.

2. LITERATURE REVIEW

Millennials and Edutainment

As we approach 2020, most college students are now officially "Millennials." According to Robinson (2018), the vast majority of students in college classrooms today would be considered as Generation Y or Z a.k.a. "Millennials" due to their birth year (See Figure 1).

Generation Name	Births Start	Births End	Youngest Age Today*	Oldest Age Today*
The Lost Generation The Generation of 1914	1890	1915	104	129
The Interbellum Generation	1901	1913	106	118
The Greatest Generation	1910	1924	95	109
The Silent Generation	1925	1945	74	94
Baby Boomer Generation	1946	1964	55	73
Generation X (Baby Bust)	1965	1979	40	54
Xennials	1975	1985	34	44
Millennials Generation Y, Gen Next	1980	1994	25	39
iGen / Gen Z	1995	2012	7	24
Gen Alpha	2013	2025	1	6

(*age if still alive today)

Figure 1 – Generation Names and Boundaries (Robinson, 2018)

Based on the fact that most current college students are Millennials, the importance of understanding how this group learns will impact teaching methods. Mottet and Beebe (2006) used an information processing metaphor of how Millennial students learn. They implied that traditional lecture delivery was not as effective as with previous generations. Hosek and Titsworth (2016) build on that concept and suggest Millennials were raised in interactive learning environments and "Are accustomed to living within a rich information environment where they can be agile in searching for, electing, and using information." This implies that Millennials will learn better where they have more control of their individual environment and have numerous options to manipulate the outcomes of that situation. The implication is that a properly chosen and implemented simulation can be an effective learning tool.

Another challenge dealing with Millennials can be their views on the role of the university versus learning. Often, Millennials are characterized as viewing the college experience as a financial choice and not a learning experience (Buckner and Strawser, 2016). Millennials use their education as a ticket to future employment rather than a true learning experience. Therefore, an opportunity for a tailored simulation is to "hide" the learning into a "real-world" type of setting that appeals to the Millennials view of education. Again, an appropriate simulation could bridge the gap between the Millennials' view of the purpose of the university with the professors' goals for learning outcomes of a specific course.

Burson, Brooks & Cox (2012) help to move the discussion of Millennial learning styles and simulation towards a more business and applied role in education. In their paper, they confirmed that Millennials are active learners with a desire to engage in relevant learning experiences. Also, Millennials are products of the digital era and capable of dealing with complex simulations and expecting rapid, if not immediate, feedback. Furthermore, they found that the increasing use of business and Marketing specific simulations have created simulations of ever increasing complexity that may confuse the students when attempting to teach and/or illustrate specific learning points. Another key point that they found was that their one-day, one-topic simulations increased learning for the students and successfully demonstrated specific Marketing concepts. Finally, a critical item was that they determined Millennials are raised with concept of learning can be fun. They specifically highlight that from Sesame Street on, the students are conditioned to expect learning to be fun. This is an important point that leads to the concept of Edutainment.

The term "Edutainment" has been in use for at least two decades. The *AMA Dictionary of Business and Management* (2013) defines it as "Educations + entertainment, a term used in media industries." Walsh (2005) provides a more robust description of the use of computer games to achieve learning goals. She discusses learning modules for children in the medical field that increased learning of various applicable skills. Egloff (2004) performed a more complex experiment to identify the benefits of edutainment using young children playing a

simulated game and then replicating the learning with actual items. The key learning point was that the skills from the game transferred to the real-world sets after playing the game, and the children enjoyed the overall process. Egloff's findings are important to this article for two reasons. First, the confirmation of enjoyment and learning (Edutainment) can work. Second, the young subjects in the original study fit the definition of a Millennial from Robinson's timeline (2018) which reinforces the previous concept of Millennials were brought up playing games that help to form the concept of learning should be fun.

In summary, Millennials have strengths and weakness just as each preceding generation. Tulgan (2004) does an excellent job of summarizing the positive attributes of this group of being technologically worldly or digital natives, fast-paced, highly educated and results driven. However, there are inherent challenges to the Millennial cohort as well: lack of focus and direction, inadequate personal and relationship skills, and defensiveness regarding constructive criticism (Tyler, 2008). These characteristics highlight the need to shift from a traditional lecture format to a different pedagogical style to improve learning with this generation. The implication is that some form of entertainment based learning would likely be more successful.

SCM & Transportation Simulation

Given the possible benefits of simulation based learning systems, an important next step in examining the literature is to identify how SCM simulations have been used in the classroom. A secondary question would be if they have been used as instructional tools, were Millennials the primary subjects. Unfortunately, the literature is less robust in this area than in the broader studies of Millennials as a whole.

The first challenge is the very large overall body of literature about transportation simulation learning. However, only a small fraction is related to pedagogical areas. The vast majority of the research can be categorized into two distinct subgroups: Simulations use of improving systems or machine learning through simulation. For example, Chen and Levinson (2006) explore the concept of using simulation to learn how transportation networks will evolve over time. On the other extreme, Wojtusiak, Warden and Herzog (2012) illustrate the concept of machine learning using transportation simulation. These extremes represent the majority of articles. In one sense, this large block of research is valuable to highlight the potential benefits of simulation. On the other hand, it also demonstrates the value of learning through simulation even if the recipient is machine based.

However, there are a small number of studies that help to frame the use of SCM software in the educational experience for students. The first is a dated, but very relevant, work looking at using a transportation simulation on a "micro" computer. In today's terms, Rutner, Gibson and Kent (1997) used a transportation simulation to educate SCM/Logistics majors on various areas of the transportation industry. They used a variety of tools to try and teach everything from ERP to core transportation skills in the classroom using personal computers. One side note is that they even identified the concept of edutainment as a benefit to their study. Their overall findings were positive.

A more recent study used a SAP/ERP Software Simulation in a SCM/Logistics classroom to help students understand the basic concepts of inventory control, forecasting, distribution and transportation planning (Angolia dn Pagliari, 2018). The authors used the SAP University Training software to perform simulations that mirrored many real-world SAP tasks as part of the learning process that highlighted many of the areas identified. The goal was to better prepare students with both the specific SAP/ERP skills and a better understanding of the various learning concepts across the supply chain. Finally, the authors had a word of caution. Just as previous studies had identified the challenges of simulation complexity, the SAP/ERP simulation had been refined through five iterations to produce a "Supplement" to the learning.

A good summary of the possible uses of specific games in SCM/Logistics/Transportation was done by Cvetic and Vasiljevic (2012). In their article, they reviewed the 47 identified games/simulations that were being used in various universities as educational tools. There are two relevant findings from the reader. First, the article does provide a database of 47 potential games that can be used by faculty. Next, it ranks them on a composite scoring system. However, the highest ranked games are more often non-computer-based simulations (e.g., The Beer Game in paper format in their study). The net result of the article was to highlight the value of the various simulations and remind readers that not all simulation based learning needs to be computerized.

To summarize the concept of using simulations in the classroom, Sweeney, Campbell and Mundy (2010) did a study on using off the shelf, commercial software in a graduate SCM class. Their findings provide an effective overview of the literature. They stated that "Incorporating commercial software in university programs presents a myriad of challenges and therefore is rarely done. However, providing students with in-depth knowledge of commercial logistics and supply chain management software improves their understanding of supply chain issues and provides a key differentiator in the marketplace." In short, simulation is an effective method to train students with concepts and provide real-world experience, but it is often time consuming and difficult to do in the classroom setting.

Based upon the two areas of examination in the literature review, there appears to be an opportunity to benefits students. Clearly, Millennials as digital natives can not only benefit from simulation, but also can gain competitive advantage on peers at other institutions. However, the key caveat that many of the literature sources highlighted was the complexity and difficulty of integrating solutions into the classroom.

3. IMPLEMENTATION

Solution Process and Selection

Given the benefits listed in the literature review, Millennials students would likely be an excellent target audience for using some form of simulation in the classroom. Furthermore, their strengths as digital natives would support the option of a computer-based model over traditional paper or board solutions. Finally, the concept of edutainment would further support the idea of a fun game/simulation to be used as the teaching tool to support course learning objectives.

In addition to the benefits that would support a computer game/simulation, the goal would be to minimize the disadvantages that were identified as well. The solution should be easily understandable and not be overly complex to the user. A second item must be the chosen software should be able to fit into the course without creating significant extra work to modify the curriculum or significantly increase the professor's workload. Finally, and most importantly, the computer game MUST incorporate the teaching points, skills and concepts that are critical to the course of major. In AACSB speak, it must support either the course's or the major's student learning outcomes in a clear and understandable fashion.

As identified previously, Cvetic and Vasiljevic (2012) identified 47 potential simulations to use. However, a large percentage were typical pen and paper simulations that were useful, but not meeting the intent of computer-based learning that could also be fun. A good example was the inclusion of the "Beer Game" as a choice. While this is an excellent tool to teach forecasting, supply chain communication, etc., the board version was not meeting the course's learning outcomes of improving understanding of transportation terminology, concepts and practices in either the paper or computerized version. Therefore, a different option needed to be identified to meet the specific goals of learning and edutainment.

After evaluating over ten various computer business "games," one stood out as being the best fit for the specific needs of the course. The program was titled "Ports of Call" or PoC for the remainder of this paper. PoC is a computer game that has existed since the late 1980's for a number of computer formats. Early in its commercial sales, it was ported to DOS and then later to Windows and works today on Windows 10 based systems. Its one major disadvantage for use in the classroom is there is not an Apple/Mac version available. (Note: our university was able to license an additional 10 copies and run PoC through Parallax. While this was not an optimal solution, it allowed Mac users the same access to the program.)

Some of the strengths to using PoC were that it was a well-established program. Therefore, there were not bugs or software crashes. Also, it had evolved over time to have numerous options and settings. PoC was well suited to creating a tailored learning experience to meet the needs of the course. For example, the basic model of the game is an ocean shipping/transport operation where each player runs his own company. In addition to the business side of the game, the various options allow plays to pilot large ships through various ports. However, the benefit of the maturity of the game was that it allowed all of the non-business functions to be minimized. Therefore, the students could "play" the ship sailing once or twice, but then focus their efforts on running a transportation company. Finally, the cost was minimal at approximately $12 per student to download and operate on their laptop (Note: Mac users were similar, but slightly different pricing and execution model.)

Ports of Call Results

PoC turned out to be an excellent choice of software. The program not only allowed the players to run a transportation company, but also forced them to work in a simulated world-wide system with freight markets, outside or external events and with or without competitor companies. The program forced players to make significant business decisions concerning which ship(s) to buy due to cost, students' ability to borrow, market availability of various types of equipment and managing the students' specific company status/reputation. In addition to the specific ship(s) the play purchased, the options included many classes of bulk freighters, oil tankers, roll-on/roll-off ships, container ships, passenger ships and a few special freight ships (i.e., LNG, etc.) Figure 2 presents a screen shot of one the many classes of ship available to purchase at the beginning of the game (Appendix). Also, it should be noted that the game allowed a free play mode that started in 1980 and had no end date limitation and newer classes of ships were added at various times in the game.

The next benefit to the game was that students were forced to buy a small bulk freighter as their starting option due to costs. While they learned the basics of running the company, they performed small loads of various commodity types of freight throughout the world. Figure 3 (Appendix) presents an example of how the students viewed the world's freight market based on the type of ship they were booking freight against and incorporated the ship's location at the time of decision. In the early stages of the simulation, the students learned about the weight limitations of freight shipment. Also, they experienced challenges with booking subsequent freight at the initial destinations which led to deadheading and future planning considerations. Finally, they quickly learned the cost of speed tradeoffs of revenues and fuel burn based on faster shipments. Each of these lessons would be reinforced by classroom learning as the semester progressed.

It should be noted that the students were required to play the game outside of class as individual players. In other words, each person operated his or her own shipping firm. And, the results were competitive and considered as part of their final overall grade. Therefore, most students were motivated to do at least marginally well to ensure they passed the project that usually accounted for approximately 20% of their final grade. One other key point was to ensure that everyone was operating on the same level of difficulty, the base or easiest settings for the simulation were used starting in 1980 with no end date. Therefore, a more motivated student could theoretically play hundreds of years of simulation time in an effort to earn the best overall score.

With mostly motivated students, they soon grew their companies. As they progressed, differing strategies were developed by the various players. Some opted for large fleets of small bulk carriers. Other moved to a few larger ships. Some students choose to move into ferries, ro/ro, tanker, container, etc. operations. The result was a diverse set of strategies and outcomes for the students. Many faced difficult scheduling problems as they learned not all containers or automobiles would have the same origin and destination pairs. Students would miss shipments and pay large financial penalties and see their company's status plummet. This would lead to a reduction of opportunities on the freight market as shippers would begin to avoid their company. Other issues would arise such as ships lost at sea. Students would overlook or deliberately reduce the maintenance budgets on their fleets and suddenly lose ships in bad weather when they became floating rust buckets. While these points illustrate a number of the major learning points, there were a myriad of additional items from Marketing to Finance and of course transportation that had to be considered as players made decisions.

At the end of the semester, each company had to prepare an overall report of how their company performed. The game helped by doing a fair job of keeping track of financial and other operational data. Figure 4 (Appendix) presents the selection screen for the reporting functions of the game. The game provided a reasonable amount of information, but for use in the classroom more detail was needed. So, each student had to use the information from the game as a starting point and create a summary document that mirrored an annual 10K report with much greater financial detail. A secondary requirement was to produce Excel charts, graphs and spreadsheets with all the annual data (i.e., 1980-20XX whatever year they ended). This helped to improve spreadsheet skills and increased their understanding of financial reporting requirements for public corporations. In addition to the basic final report, a number of leading questions had to addressed that included company strategy, changes in operations, lessons learned and other items. This helped the students to review how they operated their company and the good/bad decisions made.

Near the end of the semester, a class period was used to cover all the key learning points from PoC.

The overall result was that students ran fairly realistic shipping companies. They were forced to compete in a simulated world market for freight. They faced basic transportation decisions on freight selection, routing, maintenance and a host of related items. All of these could then be incorporated into the classroom discussion of key learning points.

4. FINDINGS & CONCLUSIONS

The PoC project was used in a senior level transportation course across a number of semesters as part of a SCM major. The net results were very positive. As discussed previously, the students gained a much deeper understanding of specific transportation concepts. These included, but were not limited to the following:

- Types of Ocean Vessels and Carriers (bulk, ro/ro, etc.);
- Challenges of weight vs space (i.e., Weighing out vs. Cubing Out of transportation equipment);
- Speed vs. Cost trade-offs both in terms of revenue impact and operational costs;
- Impact of equipment maintenance on operations and revenue;
- Fuel costs;
- Transportation and SCM industry terminology (i.e., bunker, lay days, charter, etc.);
- Roles of terminals in a carrier's network;
- Deadhead and transportation route planning;
- Freight consolidation; and,
- Various miscellaneous other items.

As a learning tool, the simulation was very effective in helping students understand many of the practical challenges that carriers face on a day-to-day basis regardless of mode.

To verify the PoC effectiveness, a short survey of the students was conducted to improve the use of the tool in the class room in the most recent semester. While it was a small sample size, it did provide a number of useful findings.

Twenty surveys were included in the dataset. All 20 students were Supply Chain Management majors. The respondents' demographics are summarized: 85% seniors, 15% juniors; 80% male, 20% female; with a self-reported GPA of 3.32; and, an average age of 22.95 including two non-traditional students.

Most of the data was specific and collected to improve the future of incorporating the simulation in the classroom. One non-intuitive finding was the comparison of students' preferences of various learning tools. Based on the literature, simulation should rank very highly. However, Table 1 – Pedagogical Tool Preferences did not find this. Using a Likert scale of 1 as the least desirable and 5 as the most, the students' responses are below.

	Tool	Score
1	In Class Lectures	4.10
2	Assignments or Homework	3.78
3	Recorded Lectures	3.78
4	Out of Class Shipping Simulation	3.40
5	Readings	2.80

Table 1 – Pedagogical Tool Preferences

It should be noted, that the data was collected at the end of the semester and there appears to be a relationship on how well a student performed on the simulation and the preference. The students that scored at either extreme, also had the most extreme views, positive and negative, on the simulation as learning experience.

Regardless, the students appear generally pleased with the process. Approximately 80% of the comments about the simulation were positive. Many of the students highlighted their learning increased and often used one of the listed skills as an example of how they better understood the transportation process after using PoC. Many also listed it as a fun experience because they enjoyed playing PoC. However, there were a number of negative student comments as well. They could be group into two categories. The first included students that just did not like PoC or the game. In their defense, after most of the learning points were achieved, students reported that the game became repetitious. They grew tired of PoC, but felt they had to continue playing to ensure they were profitable enough to earn a good grade. This may have been exacerbated by the competitive grading system instituted by the professor. This led to the second major complaint. Students that did not do well all disliked that they were graded based on actual performance compared to their classmates. Here the Millennial view of we are all winners created an issue with the grading and was not

truly a PoC issue as much as a grading format choice. Both of these could be addressed with a change in the grading format while still achieving the same learning outcomes in future iterations.

While not inclusive, some typical student responses are included. (Note: the balance of positive and negative responses was included to ensure readers understood the negative impacts. The overall ratio of responses was extremely positive.)

"I liked ports of call (sic) as a way to understand the concepts we had been learning in class."

"I really liked the Ports of Call game. It was an entertaining way to learn some important things about business and economies of scale/scope."

"I hated Ports of Call. It was not my strength this semester. I seemed to catch on too late in the process."

"I really enjoyed Ports of Call! It helped me talk about international business during my interview."

"I did not like how the class was ranked and the grades were distributed that way."

"I am unsure of a non-simulation method of learning what I did."

For the faculty member, the program was viewed as a success. Not only did it support learning in the transportation areas listed previously, but it also helped with other general business concepts, Excel skills, writing abilities and presentation proficiency as well. The overall impact on the faculty was fairly low after the first semester's learning curve was completed.

There were a few technical issues that created difficulties for the students and faculty member. Another issue with the software was identified previously with the lack of a Mac version. With the high percentage of college students owning Macs (approximately 30-40% in the latest two sections), it required the use of the College's servers as part of an IT workaround. It was effective, but did create a number of save game issues for those students. Also, initially those students had to log into the College's network from the building but that was addressed during the semester. The last technical issue was the age of the program itself. It appears that the company was no longer actively supporting it and a number of help requests went unanswered during the semester.

In addition to the technical issues, there were a few areas that PoC itself hindered learning. First, the freight market was an excellent tool. But, the revenue models were widely inaccurate compared to real-world modern day pricing. A quick check with the Baltic Freight Futures Index highlighted numerous, major discrepancies. For example, container rates were ridiculously low and bulk rates were significantly too high. While these inaccuracies did not dramatically reduce learning, they did teach some bad habits of prioritizing bulk over container operations in the belief it was more profitable for companies. These types of issues were addressed at the end of the semester with discussions on real-world pricing and how companies would adjust operations. Another challenge was that students would get lost in playing the game and forget to maintain financial records for each year even though the professor constantly stressed the game did not keep year over year data, they would forget to record the annual results needed for analysis at the end of the semester. This also illustrates that PoC is a game and not a true business simulation. Its collection of financial and operational data needed to be more comprehensive for business majors. Finally, students complained about the "fairness" of the process. The Mac users complained that they had a more difficult version to use going through the school's servers. The PC students complained they had to pay ($12) for the program and the Mac users did not (school license). This issue was mostly mitigated by the discussion that both models had limitations and trade-offs and every student was free to switch operating systems if they felt the other significantly benefited. This usually muted any fairness complaints.

The final results were that PoC may not have been perfect, but it worked very well to teach key points while minimizing complexity to the students and without much additional work on the faculty member. Overall, it was a very positive experience for the vast majority of the students. Even for the small percentage of students that did not like PoC, most admitted they did learn a great deal from using it as a learning tool.

5. FUTURE OPPORTUNTIES

The use of PoC was a success, but the limitations of the program highlight that maybe another game would work as well or better.

Given the age of PoC and limited support, it was difficult to buy the licenses in 2019. Therefore, the professor began to reexamine the selection process. After a thorough search, a few alternatives were identified. These included broader transportation games (multiple modes) and other specific modal simulations (rail, water, airline-passenger.) Also, they were screened to ensure there was at least a PC & Mac option available. Furthermore, a few were found that were Iphone/Ipad/Android capable as well. At the time of this writing, a detailed comparison of two is being conducted to see if there is a better fit going forward. It appears that "TransOcean 2 – Rivals" may be the successor to PoC. It operates very much along the same lines and addresses many of the limitations identified (financials, Mac, etc.) However, it is significantly more expensive ($30) and needs much more powerful hardware to run. So, a future article may address the change from PoC to TransOcean or a similar product.

Also, this paper was intended to provide an example to follow academics. It was not intended to be a rigorous study on the impact of simulation use in the classroom. Many of the articles had already confirmed this. However, the use of the software does present an opportunity to study the specific impacts on student retention. The reviewer comments highlighted the benefits and it presents an excellent future research opportunity.

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Appendices and Annexures

Figure 2 – Example Container Ship for Purchase
(other container classes listed in "select ship menu")

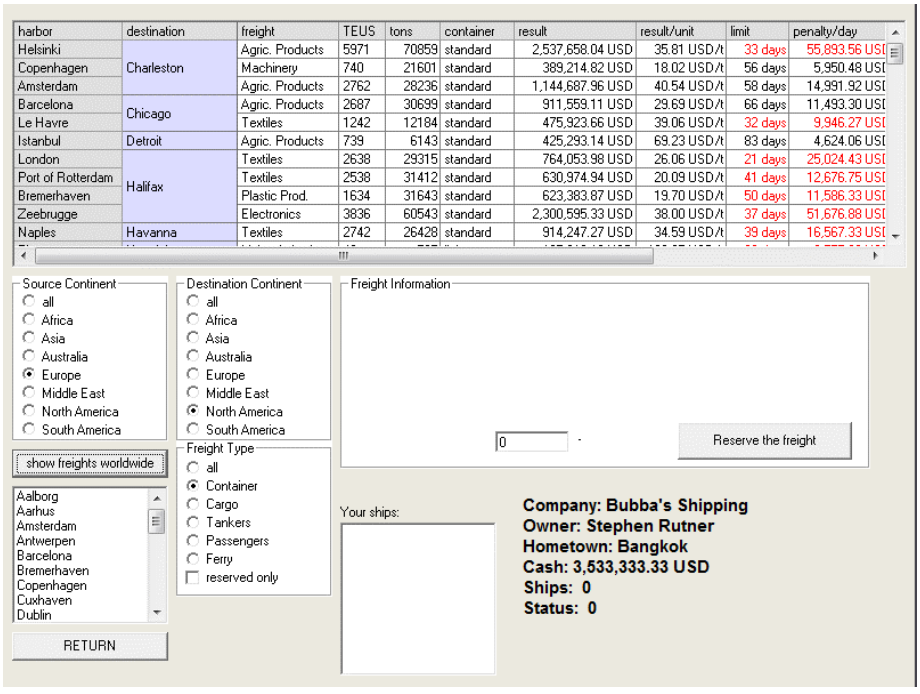

Figure 3 – World Freight Market for Cargo Booking

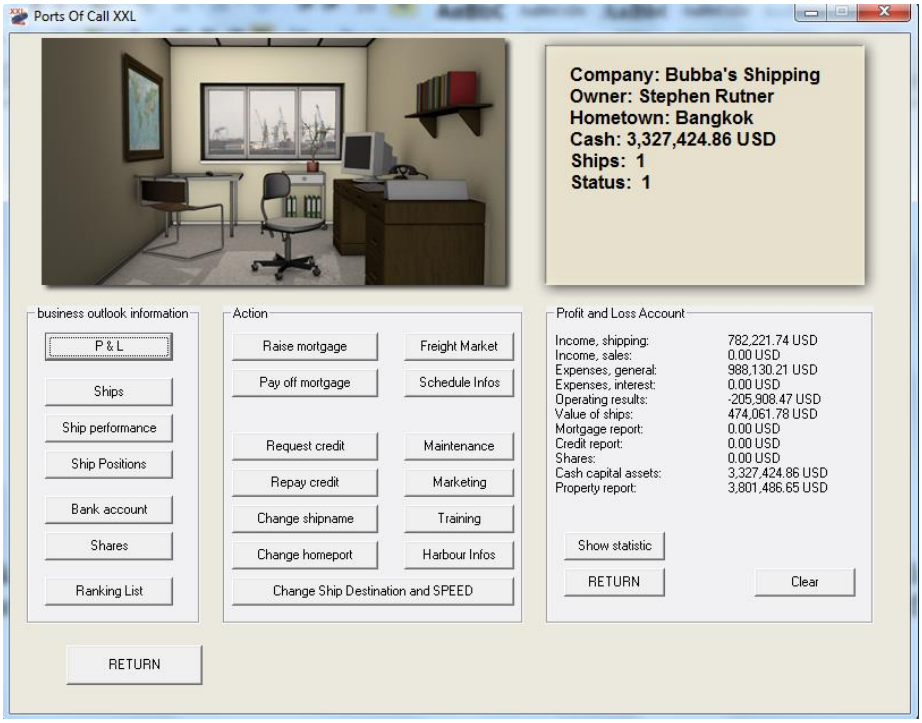

Figure 4 – PoC Reporting System Overview Page