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SIMULATION TO APPLICATION. THE USE OF COMPUTER SIMULATIONS TO IMPROVE REAL-WORLD APPLICATION OF LEARNING

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Abstract

Simulations have been used in training and education for years to aid students in gaining the skills needed to complete a task in a low risk environment. However, students can have trouble connecting the skills used in the simulated working environments to skills that are needed to be applied in the real-world environment, referred to as adaptive transfer. The simulations referred to in this study are simulated environments that mirror student skill application, not a simulation of an event that is meant to aid students in the development of concept knowledge around the demonstrated event. This study examines students' ability to transfer skills learned during a simulation activity to that of a real-world application setting. The study is situated within an introductory engineering computing course in which students are required to work within MyITLab to gain familiarity with using Microsoft Office Software, specifically Microsoft Excel. In this setting, students are expected to use high fidelity simulations, complete online course work based upon these simulations, and then complete a comprehensive exam to demonstrate skills learned with the real-world application. Guided by Kolb's experiential learning theory¹, end of course surveys were implemented to investigate student self-efficacy, the adaptive transfer process, and students' perceived ability to successfully use this software for real world productivity outside of the classroom environment. Survey questions focused upon the student experience when working with simulation software and how

using the software enabled them to use Microsoft Excel effectively. Survey results were correlated with course grades from preparation simulation activities and the final application exam. The implementation of simulated activities within the course was found to reflectively engage students with the content of the activity and provide students with a true experimental environment in order to create a real-world project. By gaining a better understanding of how students transfer knowledge from the simulated activity environment to the application environment, while capturing individual learning preferences, instructors will be able to better aid students to more effectively transition skills between different types of environments and create a more holistic learning environment that converts theoretical understanding into practical application.

Introduction

“When used accordingly, simulation can enhance a student's problem solving skills,”² (p. 1).

Within engineering education, there is a constant effort to prepare students to enter the professional world. With the adoption of the ABET EC2000 criteria and the a-k program outcomes, professional skills have moved to the forefront of the engineering curricula³. Industry advisory committee members across the curriculum suggested a real need for students to develop and maintain skills important to their specialized field of study, but can be integrated with specific business elements such as, word processing, professional writing, and budgetary

management. Scachitti (2009) also highlighted this multidisciplinary challenge stating, “whether students find employment in manufacturing, healthcare or service industries, they will all be faced with decision making and problem solving involving increasingly complex systems and rapidly changing technology,”² (p. 1). The specific problem under investigation in this paper began with a course design challenge around the need to inject professional skills into a unique course that teaches basic computing and business skills to students from three separate colleges at one university. Therefore, this course became a uniquely positioned opportunity to bring together business, technology, and general professional skills training through hands-on opportunities.

Since technical engineering courses often contain hands-on laboratory activities to emphasize course concepts⁴, it became apparent that this course should contain similar learning components for teaching professional skills, mainly using simulations. This was supported by the adaptive nature of this course, which is continually redesigned to maintain its relevance in the area of technology. Thus, new technology components are implemented every two years, while maintaining the historical elements of industry practices that do not waiver, such as the history of the Internet and Circuitry.

The course under examination not only contains a lecture component, but a hands-on computer lab component, which include the simulations. The hands-on lab component allows students the opportunity to actively use the required software through a self-paced simulation. This allows students to learn the new technology programs at their own pace. The lecture component then focuses on bringing the application of this skill into an application perspective where they can situate their new skills. The Excel unit culminates in an exam that contextualizes a problem and requires the use of the simulated skills learned.

Since Microsoft Excel is used throughout engineering curriculum to support its

application within the engineering profession⁵, the course in this study offers a strategy for teaching students how to manipulate and successfully solve real-world problems using Microsoft Excel that will be needed in their future careers. Students within this course are provided simulated experiences working within the program, then are challenged to apply the skills they learned in the simulation to solve a real-world application. This simulation experience allows students with limited prior experience with using Microsoft Excel to become familiar with the software in a low-risk environment, while allowing students with more extensive experience to quickly move through the simulation refreshing their skills in the interactive simulation environment. The simulation also allows each student to gain individualized hands-on training with Microsoft Excel that would not otherwise be practical in a class with over 300 students. The results of this study show that students are able to accurately identify skills taught to them using the simulation, as well as practical skills they were then asked to apply when completing the exam.

While simulations are not a new learning activity within engineering curriculum⁶, high-fidelity simulations for the teaching of business productivity skills (mainly the use of Microsoft Excel) appear to have limited exploration. Another unique element of this course, and the study surrounding it, is the volume of specific-student feedback as part of the overall exam improvement process. Students were asked through a discussion activity to relate their exam experience regarding how content in the exam related to previous practice offerings; thus, asking specifically about the marriage between simulation training and lecture content to that of exam content and structure. This was supplemented with a survey that explicitly targeted certain areas of the transfer between the skills used in the simulated environment and the skills used on the final exam replicating a real-world problem and application.

The purpose of this study is to examine students' perceived identification of concepts

tested within an engineering course redesign capitalizing on Kolb's Experiential Learning Theory¹ in order to examine the holistic nature of theoretical to conceptual application when using a high-fidelity simulated environment.

Research Questions

1. How does student interaction with a simulation transition the students to the application of skills in the real world?
2. What skills can students identify and connect between the simulation and a real-world application?

Literature Review

Simulations in the Classroom

"The pedagogical value of the hands-on experience that a laboratory provides is ubiquitously endorsed by educators,"⁷ (p. 541). However, true hands-on activities may not exist or be available for all type of industries, such as within health care and core engineering sciences fields due to cost, access, or ethical obligations. For these fields where direct hands-on experience is not available, simulations can offer many benefits over learning environments that provide no support or training for the learning and practicing of real-world industry skills⁸. "Simulations promote active learning, especially at the stage of debates that arise because of the complexity, interconnectedness, and novelty of decision-making. Additionally, simulations develop critical and strategic thinking skills"⁶ (p. 290). Therefore, simulations have become an expansive learning tool that bridges all industries in a flexible manner².

Despite the ongoing use of simulations in education and industry, the types and definition of a simulation vary across the literature. Curtin⁹ explored the area of multimodal which highlights optimal preparation and proper sequencing when using simulations as a learning activity. De Jong and van Joolingen¹⁰ (1998) indicated that the "the main task of the learner [is] to infer, through experimentation, characteristics of the model underlying the

simulation" (p. 180), yet no additional description was given. Unlike Kolloffel and de Jong¹¹ (2013) who examined simulations that allowed students to change variables within a circuitry environment, their description was summarized by the term "virtual lab." Within the current examination, the definition of a simulation characterized by Davidovitch⁶ (2006) will be used: "as tools enabling the acquisition of practical experience and acceptance of an immediate response of the learned system to the user's decisions and actions" (p. 290). This definition brings clarity to the term simulation and fortifies Davidovitch's statement that simulations are "recognized as an efficient and effective way of teaching and learning complex and dynamic systems for engineering education,"⁶ (p. 290).

There are many advantages when using simulations as the educator can create an environment of "practice without risk,"¹² (p. e10). Thus, supporting the notion of reducing "the gaps between the learning environment and the 'real' environment, and the availability of training in situations that are difficult to obtain and practice in the 'real world'"⁶ (p. 290). Simulations simply allow the end user to become active within their personal learning activity and in turn "support authentic inquiry practices that include formulating questions, hypothesis development, data collection, and theory revision,"¹³ (p. 136).

However, despite the rally for using simulations within a learning activity, "there is a danger that students disengage from connecting to the underlying process being simulated and instead transition into a computer game mode,"⁷ (p. 547). By moving into a "gaming" mode, the transfer of the skills learned may be limited. However, "simulations contain models that are designed to simulate systems, processes, or phenomena,"¹¹ (p. 278), allowing for the benefit of "standardization and repetition of content"⁸ (p. 151). This provides invaluable experience for the adaptive learning process. Therefore, educators must continually investigate student learning construction and ensure the activity is

meeting the intended learning objectives and goals when simulations are implemented within a learning activity⁷.

For the current investigation, the simulations require specific steps to be completed in order to receive credit; thus, requiring students to repeat specific steps in order to reinforce conceptual knowledge and procedural skills. Students are additionally provided support in the form of audio, visual, and step-by-step instruction to overcome any deficiencies in reading comprehension or for the hearing and visually impaired. Therefore, the simulations under investigation do provide opportunities to initially explore the system using a guide. The margin of testing is limited in order to highlight best procedures needed to work within the system most effectively.

Adaptive Transfer

For students to successfully learn skills in a simulation, then apply them to a real-world situation requires an adaptive transfer of skills. “Adaptive transfer involves using one’s existing knowledge base to change a learned procedure, or to generate a solution to a completely new problem (Smith *et al.*, 1997)”¹⁴ (p. 1968). This type of learning environment helps students to adapt skills learned in a simulation to produce real-world solutions that do not directly mimic the simulated or training environment. Therefore, “adaptability can involve recognizing that a rule or strategy learned in one context can be applied to an analogous situation,”¹⁴ (pg. 1967). For example, students may learn how to create a chart within the course simulation, but will then be asked to present the data in an appropriate way in the real-world requiring the skill to be used to solve a problem.

Adaptive environments are more challenging for students due to problem-solving modification requirements between using previous knowledge learned and experienced during practiced events in comparison to the skills needed to solve an unknown problem unexpectedly¹⁴. Thus, research indicates that

skill development “should contain elements of error investigation, as well as true acquisition of general application,”¹⁴ (p. 1969). However, in a problem-solving environment that introduces an element of error, negative effects may surface. The phenomenon is known as negative transfer. Negative transfer occurs when “the source (a distractor problem) and target share surface but not structure features.”¹⁵ (p. 512).

This study explores negative transfer as it is or is not taking place within this introductory course. However, this study is unique in the fact that it examines perceived exam concept content to that perceived simulation concept content and then explores the connection to self-efficacy for creating a spreadsheet environment to solve real-world problems such as trip/tour/project scheduling, or better known as the transfer appropriate processing principle¹⁶.

Using Experiential Learning Theory within the Course Design Process

Kolb’s Experiential Learning Theory (ELT)^{1, 17} provides an excellent theoretical framework to explore the course design structure and to assess student learning that will inform and guide the course design process. To actively address the iterative course redesign process, each term the instructor examines one specific aspect of the course for effectiveness of content delivery transferring to skills learned¹⁸. For the 2014/2015 academic year, a question arose regarding the conceptual knowledge transferred from the simulated environment to the real-world application, mainly the students’ adaptive transfer.

To begin, the course's current structure was examined for alignment to that of Kolb's four-part experiential learning framework. “Knowledge construction has four main phases according to Kolb’s experiential learning theory (1984) including simulation, reflection, abstraction, and experimentation”⁴ (pg. 283). According to Dhulla (2014), Kolb’s ELT “learning process often begins with a person carrying out an action and seeing the effects of

the action; the second step is to understand the effects of the action. The third step is to understand the action, and the last step is to modify the action given a new situation”¹⁹ (p. 111). We then linked these steps to the components of the course under investigation, as seen in Figure 1.

According to Kolb¹⁷, “immediate or *Concrete Experiences* are the basis for observations and *Reflections*. These reflections are assimilated and distilled into *Abstract Concepts* from which new implications for action can be drawn. These implications can be *Actively Tested* and serve as guides in creating new experiences” [original emphasis, p. 2]. The course under investigation follows a similar flow. Students begin with the Abstract Conceptualization by participating in a MyITLab simulation, they are then tested on the implications of what they learned in the simulation through Grader Assignments. The students complete six simulations and three grader assignments before applying what they learned to the concrete new experience of the Final Excel Exam, which is formatted as a real-world application of the skills learned. Students are then asked to reflect on the Exam experience through a course activity and, during the semester of the study, through a short survey.

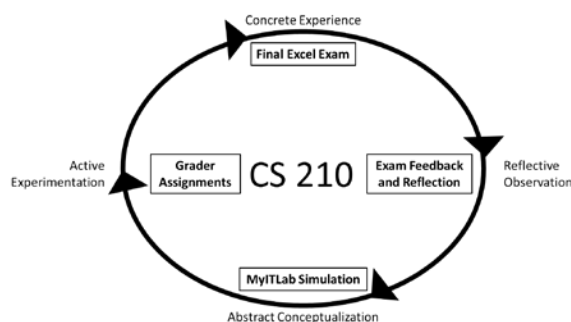


Figure 1. Kolb's Experiential Learning Cycle framing of course activities.

Methods

During the fall semester of 2014, a study was conducted in an introductory computing course for non-computer science majors. The purpose of this study was to measure the relationship between the skills learned using the simulated

environment and those demonstrated on the final Excel exam. This examination also explored student confidence, comfort, and self-efficacy for applying the skills taught in the stimulation to a real-world environment.

Survey Instrument Development

The survey used in the current investigation was developed by the author specifically for this study to focus upon similar elements between simulation and application and is not found in the literature. The survey items were selected based on the researcher's previous experience developing and facilitating the course under investigation that includes the simulations and application exam, as well as an exploration of previous research on simulations, Kolb's ELT, and general survey construction knowledge of item development to increase the content validity of the instrument. The Cronbach alpha for the instrument was 0.776. However, this reliability calculation does not include the "mark all that apply" items since they do not follow the same format as the other items on the survey.

The survey included a number of items about students' perceived ability to use the practical software taught using the simulation such as "Do you feel confident using Microsoft Excel?"; "If you were asked to complete a project using Microsoft Excel, would you feel: comfortable?; prepared?; confident?; able to complete the project?" This allowed the researchers to better understand the students' perceived ability to effectively complete activities using the target software.

The survey also included items that asked about student prior experience with Excel, how often they used MyITLab, if they attended the Exam Review lecture, and if they felt MyITLab prepared them for the exam. These items were included as control variables that would allow the researchers to examine the influence of prior knowledge, frequency of simulation interaction, and perceived preparation.

There were also two items on the survey where students were asked to “Select all the skills you feel MyITLab prepared you for” (simulation preparation) and “Select all of the skills you felt were on the Excel exam” (application). Each list contained the same 19 skills including: skills a) taught in the simulation (MyITLab) and tested with the application (Excel Exam); b) taught in the simulation, but not tested for with the application; c) not taught in the simulation, but tested for with the application; and d) not taught in the simulation nor tested for with the application. These items were included to measure student perception of the skills they were taught within the simulation and the skills required of them for the application. These items were used to highlight the gaps between students’ perceptions and the intended learning or application of the skills.

Data Collection and Analysis

The study focused upon an introductory computer science course for non-computer science majors at a small, private institution in the southeast United States. For this study, a survey was used to collect student views on the simulation experience within the course. By completing the survey, students also gave permission for the researchers to view and access their grades on selected assignments (simulation activities, Grader assignments, and final Excel exams) for the course. To increase our response rate, extra credit was offered to students who completed the survey, this was one of many extra credit opportunities within the course and students were rewarded the extra credit by giving their name and submitting the survey (not based on their responses). The survey was administered using Survey Monkey for students to complete outside of the course. An announcement was emailed to all students using an Oracle roster management interface due to size of the course under investigation (n=310). A reminder e-mail was sent two weeks later and the survey was left open until the end of the semester (approximately 3 weeks later). A total of 130 responses were collected for a response rate of 42%.

Results and Discussion

Research Question 1: How does student interaction with a simulation transition them to working within the application when used to apply those skills in a practice/the real world setting?

To address Research Question 1, researchers examined the skills the students felt the simulation helped prepared them to use. The total number of skills marked by a student that were in fact taught by using MyITLab (the *simulation*) - removing skills only on the exam or not on either - were counted and yielded a total of 17 skills. This total was then normalized dividing by 17 to create a list of values between 0 and 1 creating the variable ***Simulation Skills***.

The total number of skills on the exam (the practical *application*) were then counted - removing skills only taught in the simulation, or skills found in neither the simulation nor the exam - yielding a total of 13 skills. The number of these skills marked by students as being on the exam were counted. Again, data was normalized using the total of 13 as the divisor and the number of skills marked by the students to create the variable ***Application Skills***.

Finally, each student’s Excel Exam grade was normalized by dividing by the total number of points (50) creating the variable ***Excel Exam Score***. These actions allowed for a comparison of the skills students accurately identified as taught within the simulation and the skills students accurately identified as used with the application to the score they earned on the exam using the same numerical scale for each variable.

Each of these variables were tested for correlation using Spearman’s rho, see Table 1, using an alpha of 0.01 to indicate a significant relationship. A significant correlation with a fair relationship was found between the skills selected as those the simulation prepared students for and the skills that students selected as used in the application. This is not surprising

as many of the skills were both taught in in the simulation and tested for with the application. However, it is encouraging that students are recognizing the skills they are being taught and their application within the real-world environment that was used for the Exam.

A significant correlation with a fair relationship was also found between the skills identified by students as being used for application and the score that students received on the exam. This indicated that the more skills students were able to accurately identify as used in application, the higher their exam score was. This also is not surprising as the students who received higher grades on the exam are expected to be more familiar with the skills needed for application.

Table 1
Correlations using Spearman’s rho between the number of skills students felt they were taught in the simulation, the number of skills students felt they were tested for in the application, and their exam scores.

		Simulation Skills	Application Skills
Application Skills	Correlation Coefficient	.371*	
	Sig. (2-tailed)	.000	
Excel Exam Score	Correlation Coefficient	.206	.283*
	Sig. (2-tailed)	.019	.001

*Relationship is significant using alpha = 0.01.

However, using an alpha of 0.01, there was not a significant correlation and only a slight relationship between the skills students felt prepared for with the simulation and their score on the exam.

To further explore the relationship between the skills identified by the students, an ANOVA was run using the significance alpha = 0.01, examining individual exam scores, and student perception of their abilities using Excel between the skill identification by students whose response varied compared to the other survey

items. The significant differences are shown in Table 2.

Each of these significant relationships showed that students who felt more able, confident, prepared, and comfortable using Excel, on average, identified a higher number of skills taught in the simulation and scored higher on the Exam.

Table 2
Significant ANOVA results.

Survey Item	Variable	F	p-value
If asked to complete a project using Excel, would you feel ABLE to complete the project?	Simulation Skills	6.431	<0.001
	Excel Exam Score	6.143	<0.001
If asked to complete a project using Excel, would you feel CONFIDENT?	Simulation Skills	4.535	0.002
	Excel Exam Score	4.600	0.002
If asked to complete a project using Excel, would you feel PREPARED?	Simulation Skills	4.282	0.003
	Excel Exam Score	7.945	<0.001
If asked to complete a project using Excel, would you feel COMFORTABLE?	Simulation Skills	6.117	<0.001
	Excel Exam Score	8.006	<0.001

Research Question 2: What skills can students identify and connect between the simulation and real-world application?

To answer Research Question 2, individual skills selected were examined to identify how many students, of the 130 who completed the survey, marked a skill that the simulation prepared them for, marked a skill that was tested for with the application, and a skill indicated to be found in both of these categories. Figures 1, 2, and 3 show the number of students who marked each skill in the above categories divided by event in which the skill actually appeared. Figure 1 displays those items that were found within both in the simulation and on the application. Figure 2 displays those items that were found only in the simulation. Lastly,

Figure 3 displays those items that were found only in the application event or shown in neither the simulation nor the application event.

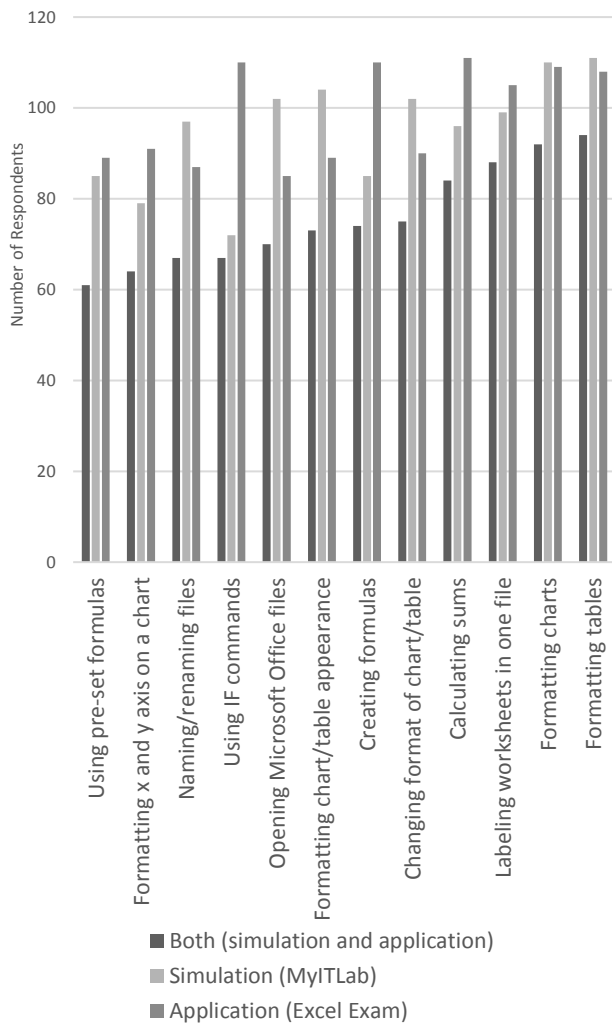


Figure 1. Distribution of respondents who marked the skills that were both included within the simulation and tested for with the application as taught in the simulation, tested for with the application, or both taught in the simulation and tested for on the exam.

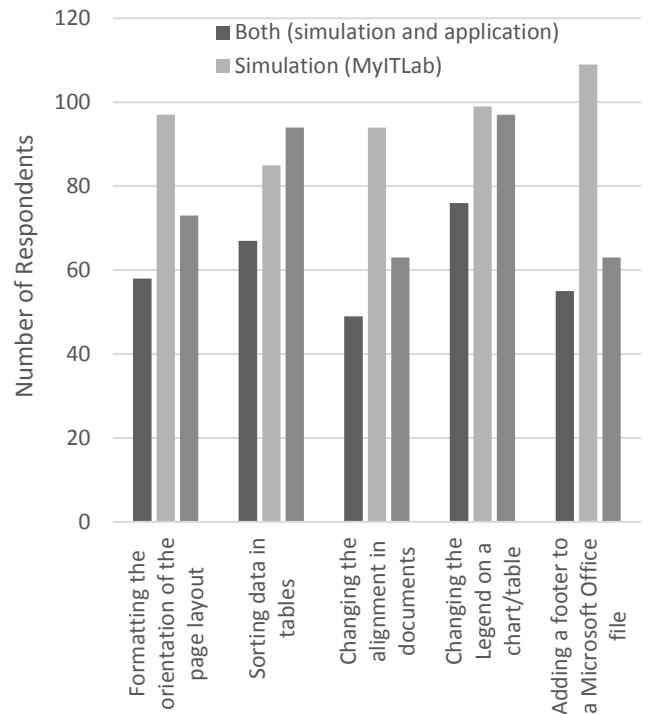


Figure 2. Distribution of respondents who marked the skills ONLY included within the simulation (NOT tested for with the application) as taught in the simulation, tested for with the application, or both taught in the simulation and tested for on the exam

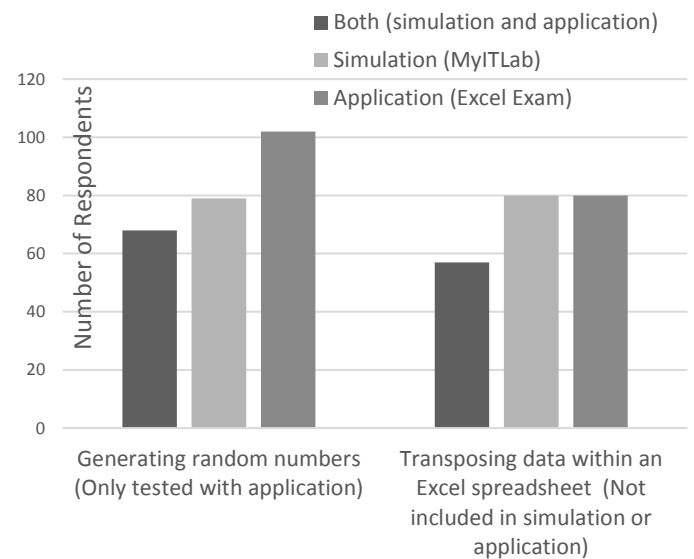


Figure 3. Distribution of respondents who marked the skills ONLY included within the application (NOT within the simulation) OR skills NOT included on within the application or simulation as taught in the simulation, tested for with the application, or both taught in the simulation and tested for on the exam

The most commonly marked skills as taught in the simulation and tested with the application were “Formatting tables” and “Formatting charts” with 85% of the total respondents marking this skill as taught in the simulation and 83% and 84%, respectively, of the total respondents marking this skill as tested for with the application (Figure 1). These elements also had the highest number of overlap of students who marked the item as appearing within both training elements at 72% and 71%, respectively. The formatting of tables and charts are general skills, requiring multiple additional skills in order to complete the task. Therefore, it is possible that these skills become a larger more memorable element within the simulations and exams.

The most interesting skill on the list is the “Using IF commands” which was included within both the simulation and the application. However, only 55% of students marked the element as taught in the simulation, and 85% marking the element as tested for within the application. This indicates that students did not feel the simulation prepared them to use this skill. This is one of the more abstract concepts, so a majority of students may have struggled to understand the application of the skill and, therefore, did not feel they learned the skill simply by using the simulation alone. Additionally, the application of the IF command, may have affected student Excel Exam scores. A follow-up examination is planned but not included in this study.

The skill marked least often as taught within the simulation was “Using IF commands” (55%). Though “Formatting the x and y axis on a chart” was included with both the simulation and application events, yet this skill was marked by only 61% of the students as being included within the simulation. However, “Formatting the x and y axis on a chart” may have been considered part of formatting a chart and not specifically noted as an individual skill by the students resulting in the lower percentage of students marking the skill. “Generating random numbers” (tested for only on the exam, and

training provided solely by the Lecturer; Figure 3) was also marked by 61% of student as being taught within the simulations. The skill not included in either the simulation or the application (“Transposing data within an Excel spreadsheet” shown in Figure 3) was also one of the least marked skills at 62%. However, overall, the selection of this skill as being included was a positive event as students were accurately marking the skills taught within the simulation.

The skills that were taught in the simulation, but not tested for with the application (Figure 2) comprised the lowest percentages of skills students marked as tested for with the application showing that students recognized and remembered the skills needed on the exam. “Changing the alignment in documents” and “Adding a footer to a Microsoft Office file” were the lowest with 48%, followed by “Formatting the orientation of the page layout” at 56%. “Changing the Legend on a chart/table” and “Sorting data in tables” were only taught in the simulation, but still marked by a number of students as tested for with the application, 75% and 72% respectively. For both of these items, students may have found these elements to be a part of the student’s routine for formatting tables/charts. Therefore, students voluntarily selected these skills as being included in the application, though they were not specifically asked to demonstrate that they could complete them. “Transposing data within an Excel spreadsheet” which was not taught in the simulation or tested for with the application and was marked by fewer students with only 62% marking it as included in the application.

Conclusion and Future Work

Overall, we found that many of the students were able to identify the skills learned within a simulation and recognize when asked to apply them to a real-world problem. There was limited correlation between the identification of skills identified as taught within the simulation and those demonstrated on the application to result in a higher grade on the test. After further exploration of the data, we found that the Excel

exam grade distribution did not follow a normalized bell curve, but a bimodal distribution with many students receiving either an A or a D on the exam. After consulting the open responses from students, we found that many students ran out of time working through the application and they may not have completed all of the tested skills they were capable of before the time ran out. Additionally with the above concern about students' inability to identify the use of the IF command within the simulation, also this observation may have created this bimodal distribution. Thus, data supports the need to update the scoring rubric for the exam to ensure points are evenly distributed based upon time and task being required. For future semesters, the exam will be re-organized to aid students in exam navigation enabling students to show as many skills as possible at the beginning of the exam; thus, aiding students in receiving all of the points they are capable of achieving. Since ample time is provided to students in which to complete the exam as indicated in previous end of course surveys, we believe students, who are running out of time on the exam, are not able to fully demonstrate all of their skills; thus, supporting the limited correlation between the skills taught in the simulation and the grades on the exam. Therefore, if the rubric is adjusted to place more emphasis on the spreadsheet setup and data creation, rather than the cosmetic formatting requests that are typically completed at the end of the project, a normalized bell curve may be achieved. Furthermore, additional simulation activities that include a greater focus upon the areas in which students believed were missing between the two activities will be explored for curriculum alignment. Overall, the implementation of simulated activities within the course was found to reflectively engage students with the content of the activity and provide students with a true experimental environment in order to create a real-world project.

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