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EXPLORING COMPETENCY-BASED EDUCATION IN AN APPLICATION DEVELOPMENT CURRICULUM

AMANDA MAHON
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Reviewed and approved* by the following:

Steven R. Haynes
Teaching Professor of Information Sciences and Technology
Thesis Supervisor

Edward J Glantz
Teaching Professor of Information Sciences and Technology
Assistant Director, Masters Programs
Academic Program Coordinator, Information Systems MPS
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

Students have different learning styles and preferences to help them learn and understand course material. Current course structures in education create restrictions on how a class session can be designed, which makes it difficult, if not impossible, to create a course that encompasses all of these students' needs because of the complexity of accounting for each of these differences. To help overcome this intricacy, this research attempts to understand how competency-based courses related to application development and programming can utilize a more personalized approach. This was explored by using an application called eAsel. To understand competency and personalization, interviews were conducted with university instructors and students to understand how students learn, how teaching is handled in the classroom, and how programming course within the college could transition to implement a personalized course flow in eAsel. During these interviews, the participants were able to interact with eAsel through a guided walkthrough. Observations of students were also conducted in a two-hundred level programming course as well as during common tutoring hours hosted by the college to test eAsel's student activity record page which helps to score student understandings of course competencies based on a five-point scale.

Overall, at the conclusion of this research study, there were positive comments toward implementing the application into the classroom for programming courses in the College of IST. Through eAsel, both professors and students are able to more easily understand the structure of the course, identify resources that they can use to learn the material they are still having a difficult time understanding, and demonstrate how well students understand course material through a rating system. By being able to assess students in real-time, both the students and professors can have faster feedback of how students can improve to master a certain competency.

However, there are also challenges identified within eAsel. For instance, class size can affect the efficiency of recording data and the ability to individually communicate with each student to build a personal connection. The effectiveness of the application also varies based on how it is implemented in the classroom, including how many and which resources are available to students, how much time is devoted to the application in and out of the classroom, and how professors are able to motivate students to reach mastery of each course competency. Although eAsel can be implemented into these classes, there are still some looming questions surrounding what this would look like within the classroom and how it would affect the current course structure. These questions must be answered before implementation can take place.

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Chapter 1

Introduction

Problem Statement

In the past several decades, researchers have gained a better understanding of different learning styles for students which help them to better succeed within the classroom (Hummel, Manderveld, Tattersall, & Koper, 2003; Keefe, 1987). These learning styles can be based on motivation, prior learning, previous experiences, and learning processes (Keefe, 1987; Vickers, Field, & Thayne, 2016). With so many different preferences and, on top of this, the combination of preferences, it becomes extremely difficult, if not impossible, to create a tailored teaching pedagogy that enables all students to succeed in the classroom. Although there are various styles in which students learn, the current educational system does not account for many of these, but research has shown how the adaption of teaching methods can help these students to better learn in the classroom (Franzoni, Assar, Defude, & Rojas, 2008). Instead, the current educational model teaches for the population mean of learning styles and negates other learning styles that do not fit into this mold and has a set structure to teaching, learning, and evaluating courses (Haynes, 2017). Because of this, many students find it difficult to succeed within the classroom. To fix this, there are several steps needed. One of which is to understand the student learning experience by working to identify what mechanisms for learning are present and which are missing by changing the focus from teacher-centered to student-centered structures.

Within the educational system, there is also a lack in understanding of how students learn, what tools are commonly used, and how the course material is reviewed to understand the necessary information. At The Pennsylvania State University (PSU), there have been some small strides that allow faculty members to better gauge student interaction with the course material through the adoption of

Canvas LMS, which allows professors to track progress through different features in the gradebook tool (Instructure, 2018). Although this enables staff to have improved understanding of student learning, there are still holes in this system inhibiting professors' abilities to fully understand the learning process. Canvas also has a feature, Outcomes, which allows professors to track student mastery of the course and monitor student proficiency of course concepts based on a four-point scale (Instructure, 2019; University of Michigan's Information and Technology Services, 2018). However, professors within the University rarely use this feature. On top of this, there is a disconnect in professors' understanding what materials students used in combination with the scores they received within the units of course material over the course of the semester.

Motivations

During my undergraduate and graduate experience, I was able to work as a College of Information Sciences and Technology (IST) tutor as well as becoming an Instructional Assistant for several programming and mathematics courses.

After several semesters of working with students during office hours and tutoring hours, I worked with different representatives within the College of IST to write a report that discussed areas within the programming courses where students have the most difficulty in understanding specific course topics and competencies (Servich & Mahon, 2016). These findings were shared with the faculty and staff of these courses. When discussing these learning difficulties, many of the professors were aware of several of the highlighted issues and have tried to account for them by spending more time and energy on these topics with little to no improvement in student grades. After these conversations, I began to wonder if there were other external factors that could cause this disconnect between teaching and understanding.

After giving this report, and for several semesters after, I looked back at the past four and a half years that I have worked as an Instructional Assistant and tutor, and the interactions that I had with

students. Over time, I have realized that these students not only have varying levels of understanding for programming and mathematics, but they also prefer and employ different learning processes when studying. Some students learn from walking through previously worked programs, others need to examine the different course readings, and others prefer to have different analogies associated with their interests, such as football. While helping these students, I found that I have to constantly change my own teaching styles to best support these students' individual learning needs.

From this, I realized that, because each student has a preferred learning method, it can be difficult for a professor to adequately address all of these preferences in a classroom of seventy-five, which ultimately hampers some of these students' ability to have an effective learning experience. Because of this, some students may become isolated and have lower performance than students whose learning preferences are met within the classroom.

Many of the students that I helped through my tutoring and Instructional Assistant positions value the ability to have learning methods that are not PowerPoint lectures or confusing book readings that list fully completed programs that the student is unable to decipher. Exercises suggested by students to help their learning experiences are stepping through example problems, diagramming code or conceptual ideas, breaking down the problem set into smaller chunks that are more manageable to focus on, understanding the background information of why a certain piece of code or process is important, and having one-on-one or small group discussions about course material.

Kharb, Samanta, Jindal, and Singh (2013) found that not only did medical students have preferences between the various types of learning experiences (i.e., visual, auditory, read-write, and kinesthetic) that can be taught through different avenues—for instance, practical/dissection, self-study, lecture, or tutorial—but that there are different combinations of these preferences that benefit different students, which can range from one to four methods for each. However, since there are so many moving parts with individual learning styles, course structure, the restraints of the course subject area, and more,

understanding how to make a better classroom environment for all students is an arduous task, especially because the answer is not concrete.

Contributions

The ultimate goal of this research is to be able to implement a tool, called eAsel (eAsel, 2019), into Information Technology courses within the College of Information of Sciences and Technology (IST) at The Pennsylvania State University. This tool will be able to better track and manage how students learn course material and complete overall course objectives. Professional staff will be able to better track what processes are used by students within this application so that they can better understand how students learn, what material students are struggling with, and how to overcome these struggles. On the student end of the application, learning will be more personalized. This is done by allowing students to choose as many or as little of the activities necessary to complete the current concept that they must master. This process happens by breaking down course objectives into smaller course competencies, then completing as many or as little of the learning objectives as needed before being assessed and certified in the competency. This process continues until the completion of the course (see Figure 1). This process is not meant to take the place of current course processes, but instead aid the students and professors as another resource for the course. By focusing on these areas, students will hopefully gain greater comprehension and retention of course material and take this knowledge for the future in course assignments, courses, and internships. This may in turn create greater success rates within the classroom as more students effectively learn and apply course material.

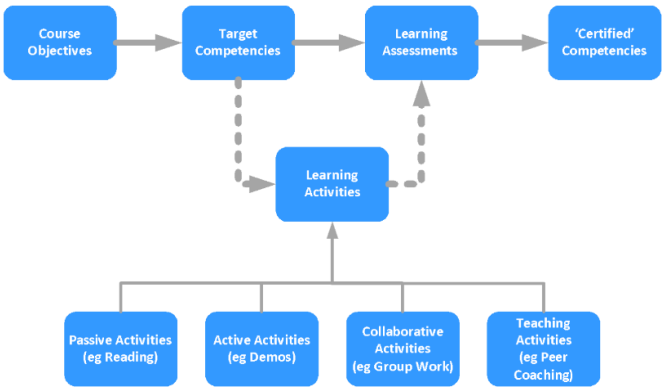


Figure 1. Personalized Learning Approach for Programming and Application Development Courses (Haynes, 2017).

Ultimately, the courses that this will be implemented in are the competency-based learning courses within the technology field where the material from a current lesson builds on the knowledge that was learned in previous ones. Many of the courses that follow this style are programming-based courses, mathematics courses, and networking courses.

At a high level, this research will hopefully help to better understand the processes that students use to learn course material and what courses could work to implement this framework to help students succeed within the classroom.

Structure of Thesis

This thesis examines how eAsel, a personalized learning environment, can help students of different learning preferences succeed within programming courses and analyze what tools students need to succeed in the classroom while professors determine what data they need to better help students in these classes. To do this, this thesis is broken up into nine chapters. The first focuses on the interests and motivations to study this subject area as well as potential contributions to the field. The second chapter examines previous research that has been conducted in personalized learning and competency-based courses. The third chapter discusses the eAsel tool and its capabilities. The fourth chapter describes the

study design used to examine this topic. The fifth through seventh chapters explore the findings from this research. The eighth chapter discusses and analyzes the collected data. The ninth chapter concludes the thesis and presents possible future work for this field of study.

Chapter 2

Literature Review

Many students have the ability to learn course material, but the structure of their course does not benefit their own learning needs (Haynes, 2017). Because of this, students often struggle to learn course concepts, which hamper their ability to continue learning concepts in classes where the material builds on itself.

Because of these learning challenges, it is important to first understand how students learn, what aspects of learning are important to their experience, and how this personalization can then be implemented into the programming coursework. To understand this, there are several guiding questions that need to be examined in the literature review. These are listed below.

1. How have personalized learning environments been implemented into educational work in the past?
2. What applications and features have been used to give students an effective learning experience?
3. How have students learning experiences been affected while using a personalized approach?
4. How has the quality of student learning been evaluated in personalized learning environments?

For this study, there are two important areas of research to explore: types of learning styles, competency-based learning (which can be broken up into several sections) and personalized learning.

Types of Learning Styles

Determining learning styles is an interest for many researchers over the last several decades. Studying student learning styles is done at all levels of education, starting in Kindergarten and continuing through graduate school. In this research, many students are able to complete questionnaires and complete tests to better determine what learning style works best for them when trying to learn. (Pashler, McDaniel, Rohrer & Bjork, 2008). In the study of learning, individuals generally claim a certain preferred learning method, which allows them to employ a certain style of thinking and processing of information (Pashler et al., 2008). Some of these learning styles also overlap with personality types. Learning styles like sensing and intuition are found in the Myers-Briggs personality test ("Sensing or Intuition").

There are many ways that students learn, some research suggests that there was more than 70 different schemas in which students use while absorbing and analyzing content (Coffield, Moseley, Hall, Ecclestone, 2004; Pashler et al., 2008). Although there are many learning preferences, the following will describe a couple of the prominent ones. Two of these types are sensing and intuition, which are competing styles. Sensing learners prefer learning concrete ideas and concepts, while intuitive learners respond better to conceptual and theoretical learning. Intuitive learners do not like repetition, while sensing learners do. (Felder & Silverman, 1988).

Another learning style is visual, learn through what they can see. For instance, these learner prefers to see diagrams, pictures, charts, symbols, demonstrations, and more to learn the topic. Opposing this is the auditory learners, who prefer to learn through sounds and words. These are students who benefit from listen to professors discuss a topic in lecture (Felder & Silverman, 1988). Kinesthetic learners learn through other tactile sensory details like taste, touch, and smell. These learners prefer hands-on activities where they can engage and interact with the material and concepts at hand (Vincent & Ross, 2001; Felder & Silverman, 1988). Many engineering students prefer to use one of these three methods of learning (Felder & Silverman, 1988).

Two other types of learning are inductive and deductive learners. Inductive learners prefer to learn though piecing the content together themselves by learning more and more content to come up with an overall picture, deductive learners are the opposite of this. They prefer to have all of the information and understand the overall concept first and use this to drill down and understand the details (Felder & Silverman, 1988).

Finally, there are also global and sequential learners. Sequential learners prefer to learn by stepping through the content in order, while global learners prefer to piece the content together in their own order. Global learners take the content as a puzzle and try to piece it together in an order that makes sense to them (Felder & Silverman, 1988).

Personalized Learning

The ability to personalize student learning in the classroom can help students to better succeed within the classroom by leveraging a student's preferred learning style (Hlady, 2012). A principal at an alternative learning facility stated, "Individualizing is a strategy; personalizing is a philosophy," when asked about their reasoning for creating a more tailored educational experience for their students through flexibility, personalized learning plans, customized curriculum, project-based learning, diverse pedagogical approaches (Hlady, 2012).

Within personalized learning, there are abilities for users to be better able to control their own environments and self-motivate, self-direct, self-regulate, and have learning autonomy with their own learning experience (Dabbagh & Kitsantas, 2012; Martinez, 2002). There are also several ways that a system can be personalized. Because of different learners using a system and each learner's different learning needs, there is no one single solution to personalized systems. This means that the objectives and activities within the course are specific based on the groups of users learning in the environment (Martinez, 2002). By using personalized learning systems, learning can be more flexible, individualized,

and student-centered (Waldeck, 2006). Over time, instructional paradigms adjust based on data collected about students and their level of achievement within the system. Some systems create personalization by suggesting content for the user while other systems allow the users to control their own learning.

One of the main instances in today's modern education system of personalized learning is the implementation of Massive Online Open Courses (or MOOCs). These courses are free online and support many users because of their accessibility, versatility, ability to self-organize and self-regulate (Daradoumis, Bassi, Xhafa, & Caballé, 2013). Some examples of MOOCs are Coursera, Udacity, Siemens, edx, CourseBuilder, Class2Go, udemy, and Lernanta (Kay, Reimann, Diebold, & Kummerfeld, 2013). From these courses, students are better able to manage their own time as they move through the material. Saadatmand and Kumpulainen (2012) examined MOOC education through an ethnographic study, where they found that students have a wide range of methods of participation including discussion boards, social-media posts, and group work. This allowed students to participate at their leisure, especially when considering their other commitments outside of the MOOC course.

Similarly, some individuals are learning on their own by having Personalized Learning Environments (PLEs) that allow them to manipulate the system to fit their own needs. One instance of this is the use of social media to share and learn new pieces of information. Through social media such as Delicious, WordPress, Twitter, blogging, and other forms, users are able to share information and gain information quickly and easily (Dabbagh & Kitsantas, 2012). The form of learning is adaptable by the student and is independently completed and configured. Other PLEs allow students to share and reuse learning tools through Learning Design (LD) Specifications, which creates a link between learning objectives and instructional values (Hummel et al., 2003).

Another personalized learning system is the Interactive E-Book Learning System (IELS), which helps elementary school students learn. This application allows students to create e-annotations, bookmark sections, learn tracking processes, create content searches, and allow for nonlinear understanding of the reading (Huang, Liang, Su, & Chen, 2012). Other research, such as Chou, Block, &

Jesness, (2012) enabled students to create a more personalized experience through the implementation of iPads into the classroom. In this case study, students were able to increase engagement, increase the amount of time worked on class materials, and increase student literacy.

Other systems create the content for the user based on their own learning needs. For instance, one application acts as a web-based recommender, called PRLS, that personalizes suggested readings from the user based on his or her learning styles and material needs (Lu, 2014). Another application called PIMS or Personalized Intelligent m-learning System has a similar function (Chen, Hsu, Li, & Peng, 2006, October). This application suggests articles for non-native English speakers based on their understanding of the language. These users are able to translate both words and sections of passages with ease to better learn the language and understand the reading.

Although there are personalized learning technologies that are helping students to gain a better understanding of the material, there are also threats to how this may look in the future. From the 2012 Data Mining Report referenced in Roberts-Mahoney, Means, & Garrison (2016), corporations are trying to privatize many of these personalized environments, ultimately transitioning free public education to private corporate spaces. By doing so, this makes the teacher irrelevant as an educator and transitions them to a technology manager of the system.

Competency-Based Learning

Competency-based learning is the format of learning that is used to describe the process of understanding and certifying the understanding of a course topic through measurable characteristics with no subjectivity (Ilahi, Belcadhi, & Braham, 2013). These competencies should not only allow students to better learn, understand course material, and apply skills, but this should also allow them to apply these understandings down the road when in the workforce (Ilahi, Cheniti-Belcadhi, & Braham, 2014). By completion, students should be considered masters of these concepts (Ilahi et al., 2013). Once a student

has a certain competency, they should be able to apply this concept to other future concepts in the course and at work. By using this educational framework, it also provides for the coexistence of quality and accountability in higher education by setting specific guiding principles in the classroom. These principles include newly acquired knowledge reflects a robust and well-rounded competency; students are able to learn at a variable pace and are supported in their learning; effective learning resources are available anytime and are reusable; the process for mapping competencies to courses, learning outcomes, and assessments is explicit; and assessments are secure and reliable (Johnstone & Soares, 2014).

This structured way of learning has been used in several subject areas including medicine, arts, communications, business, engineering, and computer science. To gain an understanding of how one could use competency-based learning, it is important to understand how this has been handled in other previous instances.

Competency-Based Learning in the Medical Field

The competency-based learning approach was first examined in the medical field, not only in the classroom, but also in hospitals and clinics (Lurie, 2012; Frank, Mungroo, Ahmad, Wang, De Rossi, & Horsley, 2010; Iobst, Sherbino, Cate, Richardson, Dath, Swing, ... & International CBME Collaborators, 2010). Much of this research focuses on how students learn medical concepts, are checked on these concepts after graduation when starting residency and as tools, processes, and medical knowledge change over time.

Within the medical field there are two focuses of competency-based research: educational practices and current workforce. Within educational practices, the research is more focused on how to standardize practices across both students and institutions. One way that this is done is by looking at the students who are entering the universities and taking courses. By looking at these students, these institutions are able to ensure that these students have the same level of basic understanding before

continuing on to harder courses within the program. Since Biomedicine is an interdisciplinary field, many students might not have the same prior understandings and experiences that other students have (Kwok, Marshall, & Chan, 2008). Some students may have more experience in business and management and have a lack of understanding of biology. To mitigate this, universities are holding prerequisite courses that are offered through Device-Based Learning (DBL) and Problem-Based Learning (PBL) (Kwok, et al., 2008). This allows these students to have a better experience with medical imaging as well as allow students to think through real-world problems and come up with solutions. By completing these courses, it allows the students to have a more standardized understanding of medical knowledge.

Beginning by identifying important practices and knowledge sets has been used across the disciplines in universities and medical schools. At one university, nursing professors who sought to create a more comprehensive understand of nursing informatics for their students completed surveys based on the importance of practical clinical training, educational training curriculums, and the role of informatics to enable their students to be on the cutting edge of healthcare technologies (Fang, Wang, Hsieh, & Hiseh, 2012). Not only did this help the students stay current and learn the best technologies to help them in the future, but it also helped to standardize the understanding of these technologies across campuses.

Improving outcomes is also done for students who have recently graduated from their university and are beginning their positions within the field. To ensure that students have the same framework understandings across fields, students have been given mentors and periodically tested on their knowledge for several years after graduation, ultimately making sure that this individual contributes effectively to the workforce (Holmboe, 2015).

Even after professionals have been in the field for several years, there are learning curves and technical changes that arise and cause a need for constant learning. This is the case with health professors who wanted to use PubMed as a way to connect hospital libraries to university libraries (Fernández-Luque, Cordón-García, & Gómez-Díaz, 2017). Many of the professionals felt unsure of how to get needed information, but, after in-person training, their professional confidence increases along with their

competency to use the system. Traffic on their Facebook page, referencing these processes also increased (Fernández-Luque et al., 2017).

Competency-Based Learning in Other Fields

Other fields have also used competencies to better measure student and employee performance. There are several programs throughout the United States that have online degrees that are structured through a competency-based learning approach. One of these is the University of Wisconsin that has a UW Flex Option that allows students to gain a degree online that follows competency-based education, the ability to self-paced learning, and has modular coursework (Johnstone & Soares, 2014). Southern New Hampshire University has a similar framework for their arts degrees, and the National Association of Manufacturers' have created a certification system to help workers achieve required skills and certifications in the workplace (Johnstone & Soares, 2014).

In universities, academics attempt to create matrices that allow for better analysis of a student's understanding, which is then applied to various forms of rubrics for group work, projects, labs, practice, and oral presentations (Vivar Quintana, González Rogado, Ramos Gavilán, Martín, Ascensión, Esteban, & Martín Izard, 2013). One instance of this is in the engineering field where multiple aspects of engineering were used to test out the rubrics. Overall, there was greater satisfaction from both the students and the professors because the rubrics allowed for better assessment of assignments and better gauges of how to improve going forward (Vivar Quintana et al., 2013).

There have also been approaches to interdisciplinary initiatives so that academics and researchers gain competencies in fields other than his or her own discipline (such as art, game computing, computer science, media, and psychology) (Vickers et al., 2016). By using the co_Lab tool to create a collaborative digital network, professionals gain a better understanding of broader topics that they could use to make more comprehensive research (Vickers et al., 2016).

Finally, lifelong learners also undergo iterative professional development to allow them to assess and give feedback on a web-based assessment model for competency within Personal Learning Environments (PLEs). This allows for self-learning, self-organization, and self-cognition, all of which impact effectiveness. Depending on the subject matter, capability and context of these competencies, lifelong learners can gain a better understanding of new topics that interest them (Ilahi et al., 2013).

Competency-Based Learning in Computer Science

There are also a few instances where competency-based learning has been assessed within the context of computer science. Similar to other fields, these studies look at how to make school-aged students more competitive and effective when entering the workforce as well as how to ensure that an employee has the right competencies for a position.

To close the gap between the workforce and institutions, one researcher suggests the use of agile methods to allow for quality of code and understanding of programming (Chatley & Field, 2017, May). By doing this, students are assessed more frequently to ensure that they are on track and are competing in the course material. The core programming skills are tested by the teaching assistants of the course where the students must be able to explain, practice, check, and learn course information before being considered "certified" in the material (Chatley & Field, 2017, May). This is similar to that of the framework determined by those already in the workforce. Research has examined how to make sure that employees' knowledge is sufficient before being able to use corporate software and change important products code. This is done by using the Competence Web-Based Assessment Framework (CAF) where employees can measure their knowledge, skills, abilities, behaviors, and characteristics based on a scale (Ilahi et al., 2014, October). By using this program, employees' activity history and interactions are saved to be monitored and used when the employee logs back on at later times.

Rationale

Based on the research found from previous studies, many schools and universities have found positive results through the implementation of personalizing curriculum and class environments for students as well as gauging student understanding of important topics in their designated field. These methods of teaching and learning also span different levels of education and fields of study. Although research demonstrates that there have been several implementations of personalization and competency-based learning, these two methodologies were never implemented into the same environment simultaneously. Because of this, two questions need to be explored:

1. Can a combination of personalization and competency-based learning be implemented into programming classes within the College of IST?
2. How can these frameworks be implemented to better the learning environment for students in these classes?

To investigate these questions, the researcher conducted interviews with students and instructors to better understand these programming courses as well as to determine how these classes could implement the eAsel application, which handles personalization and competency-based understanding in these programming courses within the College of IST. Additionally, learning observations were conducted within the classroom and during college tutoring sessions to further explore and measure of competency-based learning in this context.

Chapter 3

eAsel Tool Description

Chapter Overview

Before discussing the study design, this chapter discusses the eAsel application. In the context of this application, areas discussed include its purpose, its features, the type of data collected and stored, categories of use, and visual representations of the system.

eAsel

eAsel (eAsel, 2019) is an application designed to aid in creating a more personalized experience for its users while also allowing course instructors to monitor students' progress. The application is structured based on the personalized learning framework (Figure 2), which is used to break down course objectives into smaller concepts (called course competencies) that the students learn through various activities. The students can choose which learning activities to use to effectively learn these course competencies, meaning that the student can choose as many or as little of the provided material to understand each concept.

Once the student feels confident in his or her understanding of a competency, the course instructor and course assistants can test the student's knowledge and certify his or her understanding so that he or she can move into learning the next concept within the course. As a student works individually through the modules during class, they can ask the instructor or course assistant to assess their knowledge based on a 5-point scale (described in Appendix C). These assessments are completed face-to-face and

individually. Because eAsel is accessible on both a mobile phone and a computer, the results are entered in real-time while interacting with the student.

As students are scored on their level of understanding of these course concepts, the instructor and teaching assistants are then able to see the class's progress within the course as well as determine which activities are used by the students.

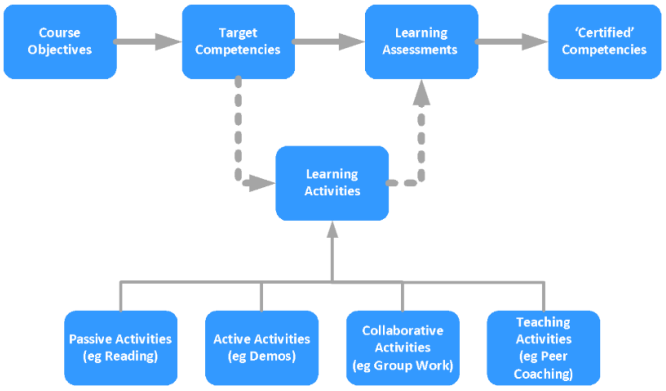


Figure 2. Personalized Learning Approach for Programming and Application Development Courses (Haynes, 2017).

In eAsel, there are three types of users: course masters, instructors, and students. In this application, course masters are users who can design, create, and own eAsel courses in the College of IST curriculum. These users are able to create the course objectives, competencies, and activities based on the personalized learning approach outlined in Figure 3-1. Once a course is created, sections can be added based on the different professors and semester sections being taught at that time. These sections are shared with these instructors, who can edit the objectives, competencies, and activities within their specific section of the course. The course instructors also have the ability to share the course with the students who are taking the course. Once these students are added to the course, they are able to view the activities within each competency.

There are three major areas of the eAsel application that help students learn course material as well as help the course instructors and support staff to gain an understanding of student progress and knowledge of various course concepts. These three areas include the student dashboard, assessment scoring (or activity record) page, and the data analytics view.

Student Dashboard in eAsel

In eAsel, courses are broken down by objectives, competencies, activities, and assessments. This breakdown is displayed on the user's dashboard in eAsel (Figure 3). By breaking down the course into these categories, students are able to move through their programming course.

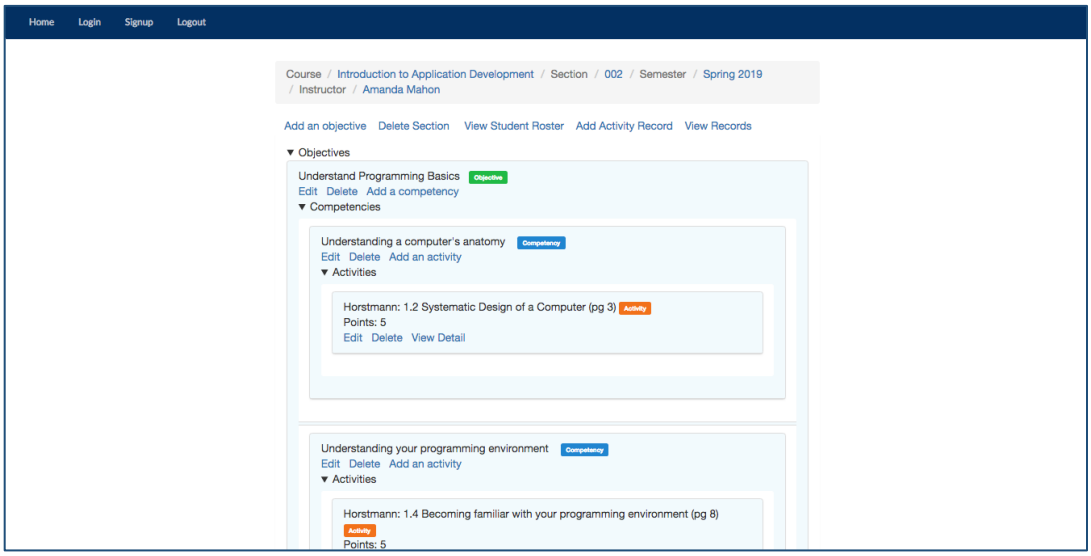


Figure 3. eAsel Application: Student Dashboard.

When a course is created, an instructor as well as a course master can create objectives, competencies, and activities (as seen in Table 1). For each activity, the instructor can choose between what type and sub-type of learning activity the material falls under, which can be seen in Table 2.

Table 1. Creating Course Objectives, Competencies, and Activities in eAsel.

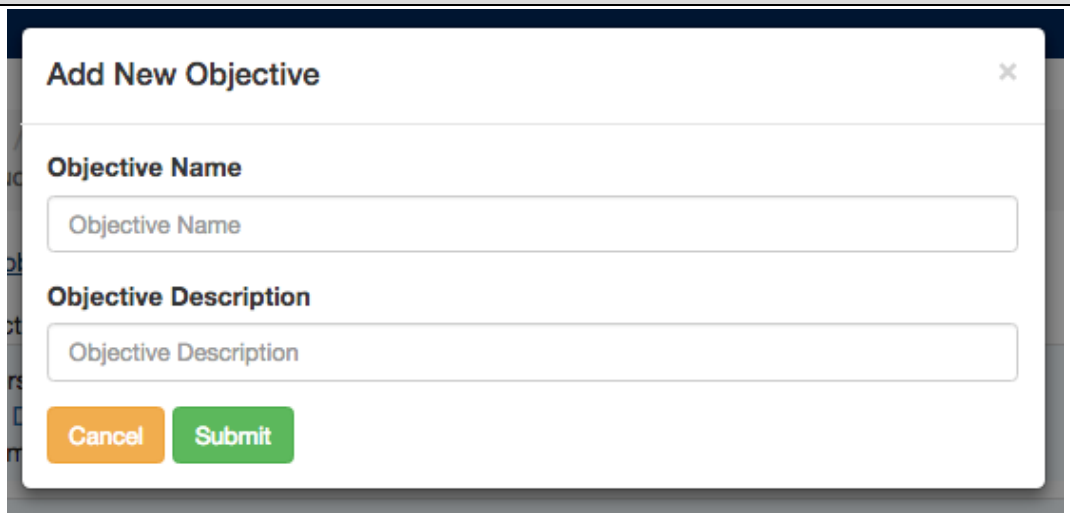
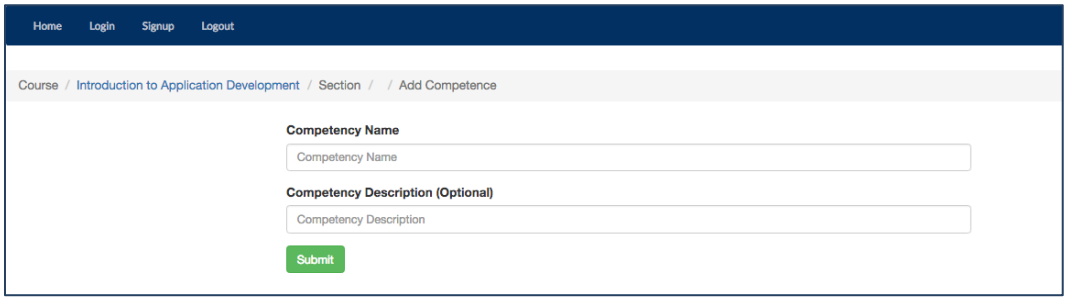
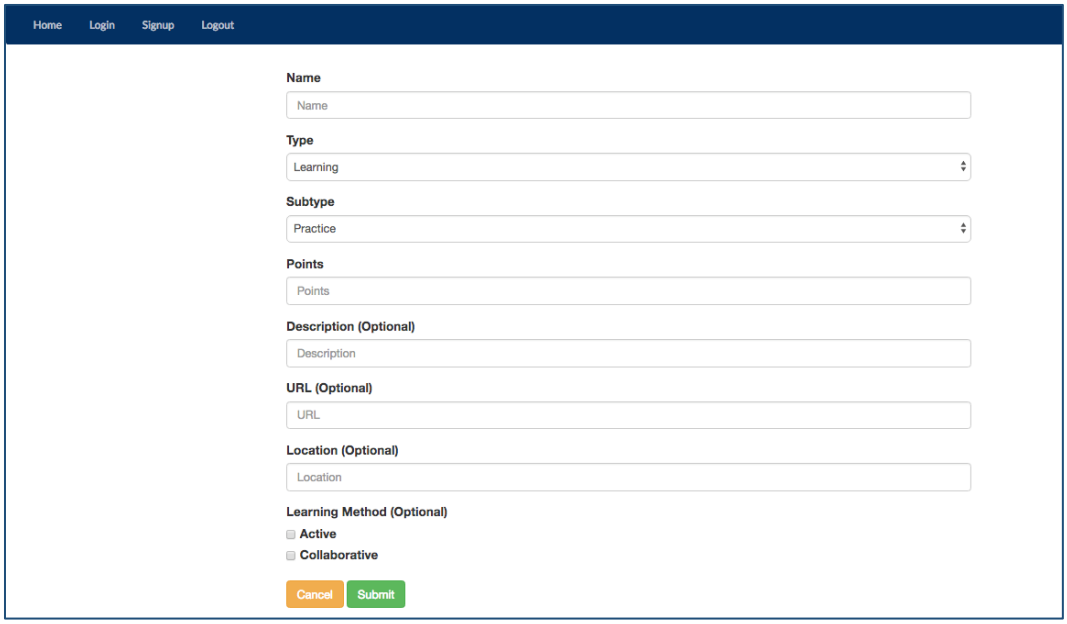
Organizing Course Materials in eAsel	
Task	**Visualization**
Creating a Course Objective	
Creating a Course Competency	
Creating a Course Activity	

Table 2. Types of Course Activities Available in eAsel.

Types of Course Activities	
Activity Types	**Activity Sub-Types**
Learning	Practice, Observation, Reading, Simulation, and Video
Demonstration	None.
Assessment	Practical and Written
Teaching	Didactic and Practical

By creating eAsel, the students can access the course materials needed to help them best understand the different concepts covered within the course by using activities that support their individual learning style. These students are not required to complete all of the activities available for each competency: they need only to complete the activities that they deem beneficial to their individual learning. As they learn this material, the students can prepare for the knowledge assessment given by the professor or course assistants.

Student Assessment Scoring Page in eAsel

As students advance through course competencies, they are assessed based on a five-point scale to score their understanding of the material (Table 3). In this rating guide, a score of one is the lowest level of understanding, and five represents a mastery of the competency. This will in turn help the student and course staff gauge the student's knowledge of the concept, and determine if the student is ready to move on to the next competency.

Table 3. Five-Point Scoring Scale to Assess Student Understanding of Course Competencies.

Scoring Criteria of Student Understanding of Course Competencies	
Score	**Description**
1	**Limited** or no apparent competency. Should review basic competency-building activities.
2	**Basic** competency but needs assistance to complete competency-related tasks. Needs significant study and practice.
3	**Competent** proficient in the competency and can explain basic rationales/mechanics. Continue to practice.
4	**Advanced** clear understanding of the competency in application and rationale/mechanics.
5	**Coach** demonstrated ability to coach/tutor other students in competency.

By using this scale, the course instructor and supporting staff can enter data into the activity record page, which records the score and other relevant feedback describing why the student received this rating. This page allows the student to be scored on a specific activity, which can be accessed by filtering the records based on the objective and competency where the students is being assessed. A visual of this scoring sheet can be seen in Figure 4. This data then is shown within the data analytics page, where the course instructor can examine both student progress of the course competencies at both the class and individual student levels.

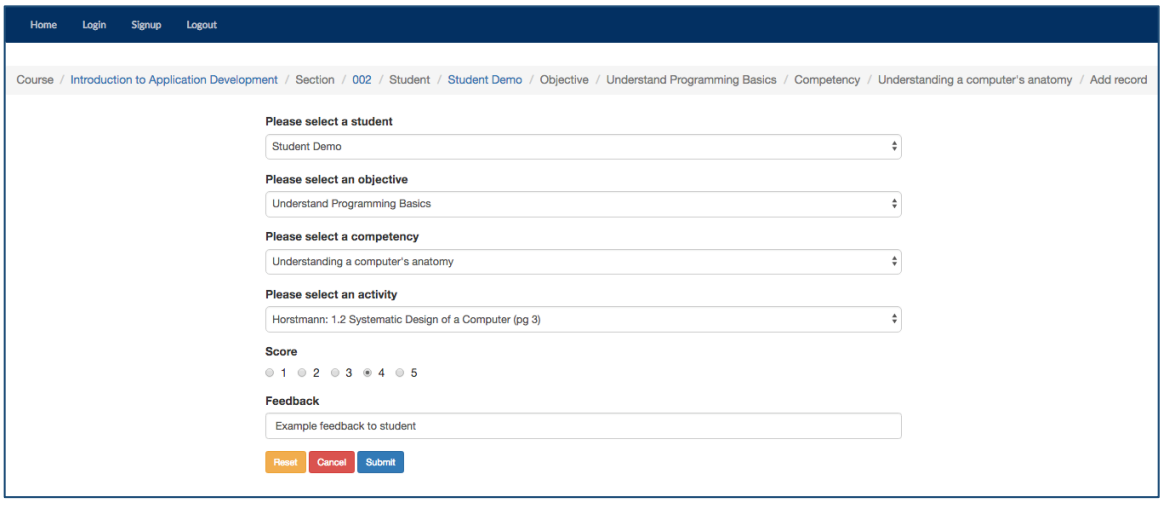


Figure 4. eAsel Application: Student Scoring Page.

Instructor Data Analytics Dashboard in eAsel

As students move through the various course objectives and competencies, their activity within the program is monitored and recorded. The course instructors and supporting staff members can then review this data to see various student interactions and progress (Figure 5). For instance, the professors are able to monitor breakdowns of class scores across different competencies and examine, which activities are used by students within the course. This data collection effort is to aid the instructor's understanding of where their students are, how they learn, and how to tailor the course to better fit student needs for later units of the course and in future semesters.

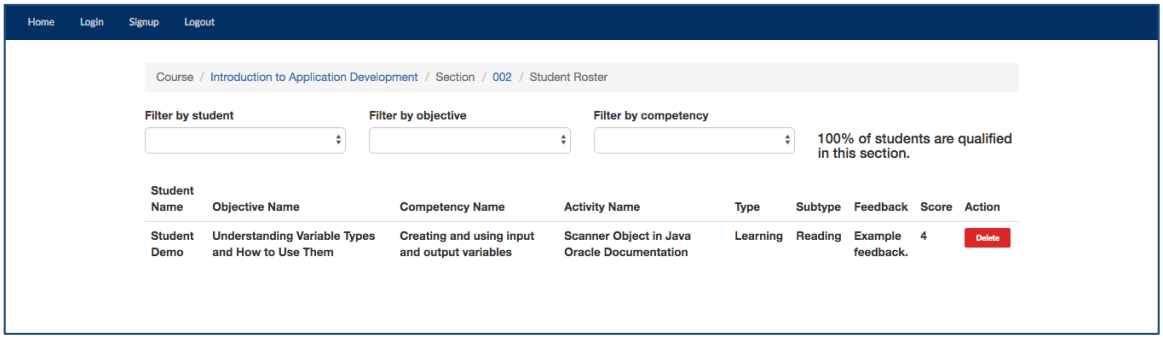


Figure 5. eAsel Application: Instructor's Data Analytics Dashboard.

Chapter 4

Research Methodology

Study Design

To better understand student learning and personalization in the context of competency-based courses (such as application development and programming-related courses) this study aims to understand how these courses can transition from their current structure to a structure supported in eAsel. To do this, the study design is broken down into three separate parts: student interviews with guided walkthroughs in eAsel, instructor interviews with guided walkthroughs in eAsel, and student learning observations assessing students' understanding of course material. Each of these elements have different objectives to help obtain the overall understanding of learning in the classroom, which will be discussed further in the following sections of this chapter.

Student Interviews with Guided Walkthroughs

Semi-structured interviews were conducted with students to better understand how courses focused on the students' individual learning methods, how competency-based courses fostered learning, how instructors currently implement personalization in the classroom (if at all), and how learning personalization could be implemented within the classroom in the future. To accomplish this, the interviews were divided into two sections, the first focusing on how students learn and how courses are currently formatted through a semi-structured interview and the second through a guided walkthrough of the eAsel application. This interview guide can be found in Appendix A.

The second portion of this interview involved a guided walkthrough (GW) of the eAsel application (Haynes, Purau & Skattebo, 2009; Prabaker, Bergman & Castelli, 2006). During this GW, the researcher described a scenario of how a student would step through a course in eAsel and be assessed by

their instructor. In the scenario for these students, the researcher stepped through the eAsel application revealing how a student would select a course competency and then the specific learning material and learning process that best benefitted that student. The researcher then demonstrated how the student would certify his or her understanding of the concept by testing his or her knowledge. Within the student walkthrough, the researcher selected a competency she wanted to understand and chose from the different learning materials to study and practice the concept. The researcher also stepped through the professor's view of the application by demonstrating how to certify the student's understanding by testing the student's knowledge and marking off that the student does in fact understand the concept so that he or she can move onto the next lesson. After a record was added, the professor was able to see an analytics page that demonstrated an overall class view of the class' progress. As the researcher stepped through the scenario within eAsel, the interviewee was able to voice his or her thoughts out loud to the researcher during the GW. These comments were voice recorded for later analysis. Screenshots of this walkthrough were administered by using Microsoft PowerPoint. There were also some clarifying interview questions that were asked to get a better understanding of the student opinions and comments towards eAsel.

Instructor Interviews with Guided Walkthroughs

Semi-structured interviews were conducted with professors to better understand what pedagogies they use, how students learn in these courses, and how learning personalization could be implemented in future semesters. Similar to student interviews, the instructor interviews were divided into two sections, the first focusing on how the courses are currently formatted through a semi-structured interview and the second through a guided walkthrough of the eAsel application, the interview guide can be found in Appendix B.

The first portion of these interviews focused on the current course structure, specifically how the faculty member instructs his or her course, what teaching philosophies he or she adheres to, how (if at all) the course fosters personalized learning, and how competencies of course objectives are measured.

The second portion of this interview involved a GW, during which the researcher described a scenario where a course master and professor construct a new course and how students would step through a course and be assessed by their instructor. The researcher stepped through both the student and faculty processes of creating a course and certifying understanding of this specific course competency. Within the student implementation, the researcher selected a competency she wanted to understand and chose from the different learning materials to study and practice the concept. The researcher also stepped through the professor's view of the application by demonstrating how to certify the student's understanding by testing the student's knowledge and marking off that the student does in fact understand the concept so that he or she can move onto the next lesson. After a record was added, the professor was able to see an analytics page that demonstrated an overall class view of the class' progress. As the researcher stepped through the scenario within eAsel, the interviewee was able to voice his or her thoughts out loud to the researcher during the GW. These comments were voice recorded for later analysis. Screenshots of this walkthrough were administered by using Microsoft PowerPoint. There were also some clarifying interview questions that were asked to get a better understanding of the professor opinions and comments towards eAsel.

Student Learning Observations

The third area of research involved an observational study with two goals. The first, to better understand how students learned course material and what level of knowledge was acquired during this learning process, and the second, to begin testing features in eAsel. To do this, students were observed in a two-hundred level programming course as well as during common tutoring hours held by the College of

Information Sciences and Technology. Students attending tutoring hours were from a multitude of programming classes within the college. During these observations, the researcher would go over course material that was learned through instruction and other available materials in the course through Canvas and eAsel. Based on these interactions, the researcher would score the students' understanding of the material after each interaction based on the five-point scale used in eAsel. This data was then entered into eAsel's activity records page. The interactions were entered in real-time either on a mobile phone or on a computer desktop available within the classroom.

The purpose of this research was to begin testing the features within eAsel. Because the application could not be fully piloted within these courses, these observations were used to start testing specific features. By testing the process of entering activity records into the application, this allowed the researcher to better understand how this feature would work in the classroom and what its implementation would look like in a busy, live working classroom.

Participants and Recruitment

Participants were recruited based on their relationship with programming courses in the College of Information Sciences and Technology (IST). There were two groups of individuals that were specifically recruited for this study: current faculty members and students who have taken or were currently taking College of IST programming courses.

There were different recruitment processes for each area of study and their involvement within the study. For the professor interviews and application walkthrough, the faculty members were contacted through email. Student participation in the interviews and walkthroughs were solicited through their class period. To do this, the professors were emailed to ask for approval of involvement within the study, and the researcher then presented information about the study and solicited volunteers during a class session.

For the course observation, the researcher discussed observing the classroom with the professor before the start of the semester. The researcher then solicited students to participate by presenting the project at the beginning of the semester.

For the tutoring observation, the researcher discussed observing students during tutoring sessions with the program advisor. The researcher then solicited students to participate based on those who attended these sessions throughout the semester.

Faculty Members

The involvement and number of faculty members within this study was a sample of convenience. Because there are a limited number of faculty members within the College of IST, and an even more limited number of faculty members who teach programming courses, the researcher contacted each of these individuals and was able to work with 5 professors who have taught 11 different programming and design courses in the College of IST for the interviews and walkthroughs of the eAsel application.

Students

Each of the students were chosen based on their enrollment in programming courses within the college. From solicitation within the various programming courses, 32 students were interviewed across 2 programming courses. The variety of these courses were based off of which courses were offered during the spring 2019 semester and which professors agreed to allow student involvement within the study.

For the course observation, students were all enrolled in the course being observed by the researcher. During this observation, 41 number of students were monitored and their understanding of the course concepts were recorded through the activity record sheet on eAsel.

For the tutoring observation, students attended college tutoring sessions. During this observation, 15 number of students were monitored and their understanding of course concepts were scored through the activity record sheet on eAsel.

Data Analytics

After collecting the data, there were different processes completed to clean, organize, and analyze the data points. These processes were different based on the different forms of data collection: interviews and observations.

Interviews

Each of the interviews was audio recorded and auto-transcribed through Otter Voice Notes, an iOS application (Otter Voice Notes, 2018). These interviews and transcriptions were reviewed and cleaned to ensure that the audio matched the transcriptions. From there, the interviews were coded based on concepts that were common and unique between all of the interviews. This is a framework that is outlined in Hallberg (2006), called Hierarchical Coding Process, which compares qualitative data based on line-by-line coding, then into conceptual coding, and narrowing this down into breaking down the codes into categories These concepts were then categorized into different themes that helped to better describe the collected data. These findings can be found in Chapters 5 and 6.

Student Learning Observations

Each observation was recorded within the eAsel application under the activity record page. Because of this, data was collected on the activities used during student interactions, their scored

understanding of the material, and any feedback from the individual session as well as feedback about how to better capture student data in the future.

To analyze the data that were collected, the researcher focused on the interaction with the students and the process of entering the student records based on that interaction. These data collected by the researcher involved the approximate amount of time it took to enter information in the form, positives and negatives about the activity record page, and benefits and drawbacks of entering student results during the class period based on these student interactions.

Chapter 5

Results of Student Interviews and Guided Walkthroughs

Chapter Overview

This chapter represents the first of three that explore the results collected from this study. This chapter focuses on the student interviews and guided walkthroughs, the next looks at the instructor interviews and guided walkthroughs, and the third chapter reports results of the student learning observations during a programming course and College tutoring sessions. This chapter specifically investigates the student interviews by discussing the common themes that were collected from the interviews, and the impressions and feedback given for the eAsel application during the guided walkthroughs.

The student interviews were conducted during the spring 2019 semester, where 32 students were interviewed about their experiences within programming courses that they have taken, their preferred learning style, as well as completing a walkthrough of eAsel. The students were recruited from the entry level Java programming course, IST 140, and the intermediate level Java programming course, IST 242, offered through the College of IST.

Student Data

From the students that participated in this study, there were students across each of the student class standings. As seen in Table 4, approximately half of the students were freshmen, and a little less than half of the students were sophomores.

Table 4. Breakdown of Class Standings of Students who Completed Student Interviews.

Student Class Standings	
Class Standing	**Number of Students**
Freshman	15
Sophomore	13
Junior	3
Senior	1

The students also had a variety of majors and minors, both within the College of IST and throughout the University. As seen in Table 5, over half of the students interviewed were Cybersecurity Analytics and Operations majors, followed by the IST major. Only 3 of the students that were interviewed were taking the IST Design and Development option, which focuses on application development and programming skills.

Table 5. Majors of Students who Completed Interviews.

Student Majors	
Major	**Number of Students**
Cybersecurity Analytics and Operations (CYAOP)	17
Analytics and Operations	10
Law & Policy	4
Economics	2
Geopolitics	1
Information Sciences and Technology (IST)	8
Integration & Application (ITINT)	4
Design & Development (ISDEV)	3
People, Organizations, & Society (ISPP)	1
Security and Risk Analysis (SRA)	3
Intelligence Analysis & Modeling (IAM)	2
SRA Pre-Major	1
Data Sciences (DATSC)	1
Applied Data Sciences	1
Division of Undergraduate Studies (DUS)	2
Pre-IST	1
Pre-Cyber	1
Human Centered Design and Development (HCDD)	1
Business	1
Supply Chain Management	1

Additionally, several students also had a minor that they were obtaining. Many of these minors were the IST and SRA minors offered through the College of IST. A breakdown of this data can be seen in Table 6.

Table 6. Minors of Students who Completed Interviews.

Student Minors	
Minors	**Number of Students**
Security and Risk Analysis (SRA)	4
Information Sciences and Technology (IST)	2
Business	1
Communication Arts and Sciences (CAS)	1
Economics	1
Health Policy and Administration (HPA)	1
Labor and Employment	1
Political Science, Global Security	1
Recreation, Tours, and Management	1

The students who participated in this study were currently registered and have taken one or more programming classes offered throughout the University. Almost all of the students had taken the introductory Java programming course, IST 140, which is offered through the College of IST. Over half of these students have also taken one or both of the intermediate Java programming courses offered through the College, IST 240 and IST 242. Another half of the students had taken or were taking the College of IST SQL database management course that teaches SQL, PHP, and HTML/CSS. Other students also gained a background in Python through Computer Science and Cybersecurity courses. One student, who had a background in business, took courses that taught R through the Smeal College of Business. This data can be viewed in Table 7.

Table 7. Programming Courses Taken by Student Interview Participants.

Completed Programming Courses	
Courses	**Number of Students**
IST 140: Introduction to Application Development	31
IST 242: Intermediate & Object-Oriented Application Development	17
IST 210: Organization of Data	16
CMPSC 121: Introduction to Programming Techniques	5
CMPSC 122: Intermediate Programming	3
CMPSC 131: Programming and Computation I: Fundamentals	2
CMPSC 132: Programming and Computation II: Data Structures	1
CYB 100: Computer System Literacy	1
BA 421: Project Management	1
MIS 204: Introduction to Business Information Systems	1
IST 240: Introduction to Computer Languages	1

Personal Learning Style Preferences

During the interview, students were asked about their personal learning styles. There were many learning styles that these students preferred to use (Table 8). However, some of the most popular ones were those that involved seeing examples of code for problems that had been solved. These examples included pre-completed code or code that was written in real-time and explained why each line is needed within the context of the problem. Another method that goes hand-in-hand with this is stepping through and explaining the code line-by-line (and hand tracing each element) to better understand each part of the line, where it comes from, what it does, and why it is needed in the program. Other examples of popular learning styles involved face-to-face interactions. These interactions varied from individual conversations with family members, friends, peers, professors, and teaching assistants to group settings with several students sharing ideas about different code and concepts.

Table 8. Preferred Learning Styles Used by Students from Student Interviews.

Student's Preferred Learning Styles	
Learning Style	**Count of Occurrences**
Seeing Examples of Written Code and Concepts	15
Using Visuals to Understand the Code	11
Face-to-Face Interaction	10
Using Class Textbooks and Resources	10
Researching through Online Resources	6
Video Based Learning	3
Auditory Learning	1
Memorizing Coding Concepts and Structures	1

Another popular learning style listed in Table 8 is using resources such as the class textbook, other technologies available within the course, and online resources. These resources are further outlined in Table 9. Specific resources that students used included Google, YouTube, StackOverFlow, Zybooks, Lynda.com, the Java Library, and Canvas LMS.

Table 9. Resources Used by Students Outside of the Classroom.

Resources Used by Students	
Resources	**Number of Students**
Online Resources	41
Google	14
YouTube	9
StackOverflow	6
geekforgeeks.com	3
w3schools	2
CodeAcademy	2
cplusplus.com	1
Stack Exchange	1
code.org	1
CourseHero	1
Chegg	1
Face-to-Face Interactions	30
Talking to Peers, Friends, or Family Members	16
Professor, LA, or TA Office Hours	8
IST Peer Tutoring	5
Individual Tutoring	1
Class Resources	13
Class Textbook (Horstmann)	2
Java Library (Oracle)	2
Reviewed Class Examples	2
Zybooks	2
Lynda.com	1
Korean Textbooks	1
Class Lecture PowerPoints	1
LMS Canvas	1
Class Logs	1
Individual Interactions	1
Learning Individual	1

Class Structure

Part of the interviews focused on understanding the structures of the programming courses with which students had prior or ongoing experience. Specifically, these questions looked into the activities that were completed during course lectures, challenges that students faced during the semester while

learning course material, their ability to retain this knowledge over the course of the semester and in future classes, and improvements to ensure these courses better reflect their needs as a student.

Outline of Current Course Structures

Students were asked to discuss how a normal class period looks for their class(es), including the structure of the different activities and teaching styles that were used. They were also asked if these course structures aligned to their preferences in terms of learning styles. Of the 32 students, 14 students said that their courses have aligned to their preferences, 7 students said that the courses did not align to their preferences, and 11 students had mixed reviews.

Table 10 describes some of the methods that are used within the classroom based on the students' experiences and perceptions of the course. Over half of the students said that their courses had code walkthroughs. During this time, the professors demonstrate how to program a specific problem in the context of the current unit being discussed in the course. In the walkthrough, the professor describes how to code the problem and what each piece of code represents in the context of the solution. Other popular activities included PowerPoint lectures and in-class activities that were hands-on and allowed the students to practice the different coding concepts being covered.

Table 10. Methods that Professors Use in the Classroom, Based on Student Perception.

Teaching Methods Used in the Classroom	
Methods	**Number of Students**
Code walkthroughs	18
PowerPoint lectures	8
Hands on activities	8
Question and answer sessions	4
Complete labs and assignments	3
Readings and Zybooks	2
Group work	2
Give code, but must figure it out on their own	2
Quizzes and exams	2
The class period focuses on theory rather than doing practical problems	2
Individual interaction with the professor	1
Self-learning videos	1

During this time in the interview, many students discussed elements of the course they wish were more prevalent or were present within the course. Many of these comments were focused on the hands-on activities, specifically through more examples and practice where the students could learn how to implement different coding concepts in different contexts. As seen in Table 11, many of these students suggested having more real-time coding walkthroughs of examples, more line-by-line explanations of code, and more individual practice problems to test their own personal knowledge of the concepts. Another interesting response was the inclusion of more interactive course periods where students would be able to interact with the professor and class during coding walkthroughs or other class discussions. This activity could also be implemented through the use of group work when going over and completing problems in class.

Table 11. Methods of Teaching that Students Would Like to See Used in the Classroom.

Methods of Teaching that Students Want in the Classroom	
Methods	**Number of Students**
More coding walkthroughs of examples	7
More PowerPoint and theory-based learning	6
More line-by-line explanations of code	6
More practice that is related to the homework and challenging	5
More paper and pen type of activities	2
More explanations of homework solutions	1
More personal connection with the professor	1
More group work	1
More interactivity	1
More time for comprehension of the examples	1
More study sessions	1
More readings and resources	1
More consistent course structure that improves the flow of the semester	1

Challenges When Learning Course Concepts

Students discussed different challenges based on the course structure and process of learning to program that at times made it difficult to learn in the classroom. Of the students interviewed, 5 stated that they had not experienced any challenges that inhibited their ability to learn in the classroom. The other 27 students explained several impediments that made it, at times, difficult to learn. These challenges are outlined in Table 12 and further explained below.

Table 12. Challenges Faced by Students When Learning Coursework.

Student Challenges in the Classroom	
Challenges	**Number of Students**
Lack of Background Knowledge	16
Time Constraints	11
Bringing It All Together	5
Difficulties with Resources (or lack of) in the Classroom	4
Cultural Differences	2
Learning Multiple Languages at One Time	1
Lack of Interactivity	1

Many students had struggles with time. Some felt the course progressed too quickly, others felt it progressed too slowly, and others felt that there were changes in speed throughout the semester. Much of this speed was because of the difficulty of the information, inability to cover the vast amount of information required to understand the concept during the class periods, and the learning curve of students who are new to programming. Courses' pacing tied together numerous other challenges students felt as they learned programming in a classroom environment: timing affected their ability to acquire basic knowledge within the coursework needed to progress to more advanced topics, and this impeded their ability to conceptualize programming in a unified, concrete way. Additionally, for those students who felt the material was covered too quickly, the ability to use classroom resources fully or effectively suffered.

Several students highlighted the difficulty of bringing all of the concepts together. By this, the students meant that it was difficult to determine how the code interacts with each of the different parts relating the context of the problem. In programming courses, many of the new concepts build on previously learned concepts from earlier in the course or other preceding courses. Because of this, the students felt that sometimes it was difficult to know how to build these different concepts and put them together so that it would create one cohesive solution.

Some students had challenges because of a lack of knowledge about the concepts. These students felt that they would have benefitted from having a more in-depth explanation of the theory and background related to the concepts and have an explanation of how these concepts relate to the real world. Other students felt confused when different course resources explained the same concepts in different ways, ultimately resulting in the need for clarification on the topic. Because of the lack of knowledge, students had a hard time taking the background knowledge and applying it to a practice problem. Several students wished that they were given the opportunity to have more practice problems to better learn the current unit. This would also help with the rift between the level of difficulty of the assignments, which were often times several degrees more difficult than the simple examples covered during a class session, causing them to need more guidance on how to start the different assignments and class problems.

Another challenge was the resources that were available within the course. Some students felt that there was a lack of resources, such as a textbook, or that the references that were provided (such as Zybooks) were at times confusing. Outside of the resources provided in the classroom, a few students also had challenges being able to find relevant information online because they did not know what to search for or how to locate it.

Other smaller challenges that students encountered was cultural differences where the professor had an accent, or the student knew English as their second language and had to take extra time to understand the different concepts within the course. Another challenge is when students are learning multiple languages at one time. One student said that she was learning Python at the same time as she was learning introductory Java. The differences between these languages at times made it difficult to switch between the two. Finally, some students noted that there was a lack of interaction for the students within the classroom. Much of the time there was passive learning. Instead they would prefer to have more interaction during lectures, examples, and other activities in the course as well as the implementation of group work.

Course Pacing

During the interview, students discussed how the pacing of the class felt to them. Course pace can directly relate to a student's ability to comprehend course material. If a student does not have enough time to learn, synthesize, and review the material, he or she may have a hard time using this knowledge in subsequent lessons of the course and major curriculum. From the interviews, 3 students said that the course progressed too slowly, 14 students felt that the course progressed too quickly, 11 students felt that the course had periods that were both slow and others that were fast, and, finally, 4 students felt that the course was well paced.

Of the 14 students who thought that the course was slow to variable in speed, 5 students had previously taken a programming course where they learned much of the material that was covered in their current programming courses. Three students did not have previous experiences with programming, but they felt that there were several points in the semester where the courses were progressing at a slower rate than preferred. When these students experienced the slowness of a course, some students stuck with the pace of the course and would work on coursework for other classes or they would stick with the pace of the course and try not to deviate. On the other hand, other students would try to challenge themselves by finishing a class example before the professor, would try to absorb new details during the lectures in class, ask if there were other ways to complete the programs through different Java methods, and try to make some of the homework and other assignments more challenging by adding additional concepts to the program.

Some of the students felt that the course was well paced. When they would reach a barrier in learning concepts or completing assignments, they would continue to try and figure out the code before the deadline.

Of the students who thought that their courses moved at a fast pace, many of the students felt that there was not enough time allotted for the class during a single week and that the units moved too quickly making it difficult to deeply learn and review the material (Table 13). To help stay on track in the class, students would often times reach out to their professor or other peers while they continued to review the material (Table 14).

Table 13. Explanations of Challenges with Courses that were Fast Paced.

Explanations of Challenges Faced Based on Course Speed	
Reasons for Fast Pace	**Number of Students**
Fast modules, not enough time during the class week	7
No deep learning of the material	3
Modules built on each other	3
Time of the unit did not change as the difficulty increased	3
Time consuming assignments	2
Lack of time for interactivity/hands on work during class	1
Lack of time to review material	1

Table 14. Steps Students Took to Keep Up with Course Pace.

Steps Taken by Students to Catch Up on Course Material	
Activities Completed by Students	**Number of Students**
Communicating with Peers	9
Office hours	6
Prepared for Class More by Researching, Reading, or Zybooks	5
Working through the Code or Previous Examples	3

Retention of Course Material

Retention of material is also a hardship for students who are taking programming courses. Because the units within these courses and the levels of the programming courses all build on each other, this can cause difficulty for students when moving onto new units if a past unit is still a little confusing to them. As referred to in competency-based learning literature, this framework attempts to achieve a level of understanding where the student can use the information that they have gathered at any point in the future, not just for the current lesson or exam where the student is being assessed (Ilahi et al., 2013; Ilahi et al, 2014; Johnstone & Soares, 2014). Because of this, retention of knowledge is a cornerstone to understanding and achieving mastery.

When students talked about retention of knowledge during their interview, 22 students said that they have experienced issues with retention, and 8 students stated that they had not experienced any

problems. As the third student interviewed introduced the theme of retention, the sample size for this particular question was 30, not 32. After that point, the question was added for subsequent interviewees.

Of the students who had felt that there was no issue with retention, 2 students felt that the building material made learning easier when learning new concepts because of the base knowledge they had already obtained. Four other students felt that besides minor reminders about syntax they did not have problems when moving onto new units within the course.

Other students experienced issues with moving onto new units, their reasons can be found in Table 15. Several of the students had difficulties because they felt they did not have a firm understanding of a past unit, making it difficult to move onto new concepts that incorporated both the information they had not yet mastered as well as the new concepts that were now being taught and covered in assignments.

Other students have issues with fitting all of the pieces together. They felt they had a firm understanding of the concepts as individual parts, but when they used them together in a single problem they were unsure of how to link them to create one working solution. This was especially difficult for the IST 242 students who had assignments that would build on each other. If there were errors in previous assignments that they did not know how to work through, they first had to fix those solutions before moving onto the next assignment for the course.

Table 15. Student Reasons for Lack of Retention Between Units.

Student Reasons for Lack of Retention of Programming Concepts	
Reasons	**Number of Students**
Difficulty fitting all of the pieces from different concepts together	7
Did not experience deep learning in previous units	6
Understanding the logic for project scope	4
Assignments built on each other making it difficult to move on if previous assignment was unfinished or had errors	4
Missing understanding of theory for each concept	2
Finding the missing gaps of knowledge from previous units	2
Lack of understanding of how to implement based on theory knowledge	2
Not knowing where to start a problem	1
Lack of feedback on previous units or assignments	1

When students had these experiences, they tried to get back on track with the course in several ways (as seen in Table 16). Many students would review the class notes and examples that were covered in the units that they had forgotten or were trying to use in the new context. They would also research more information about these topics. Other students tried to complete more practice problems in the areas that confused them. Finally, others tried to attend their professor's or teaching assistant's office hours; tutoring sessions; or interacting with family members, friends, or peers.

Table 16. Methods Students Used to Catch Up on Course Material.

Methods Used by Students to Catch Up on Course Material	
Methods	**Number of Students**
Reviewed notes and examples from previous units	9
Practiced more on their own	5
Researched topics online or through videos	4
Prepared more for class than previously	3
Went to office hours	3
Attended tutoring sessions	2
Talked to family, friends, or other peers	2

Possible Improvements to Programming Courses in the College of IST

As students discussed learning in the courses that they have taken, the students also discussed how these courses could be changed to better help them learn within the classroom. These comments are listed in Table 17. Many students felt that their performance would improve if there were more resources available to the students including a course textbook, additional videos discussing the course units or other related material, notes from class, or the implementation of Zybooks into the IST 242 course.

Table 17. Suggestions to Improve the Course Structure to Better Help Students Learn.

Suggestions to Improve Programming Classes for Students	
Improvements	**Number of Occurrences**
Course structure	32
Course resources	18
More examples of code	17

Other students felt that a change of the course structure would be beneficial, which was cited by breaking down the course into specific concepts, breaking down the course assignments into smaller concepts rather than large labs, having slower or self-paced units to allow for more synthesis of the material, allowing students to skip sections that they already understand, making the course more interactive during the class period by having them work in groups or discuss concepts in class, including more concept theory or diagramming of how concepts are used, having more one-on-one attention with the professor, making sure that professors do not assume the level of students' knowledge of different concepts in programming, and ensuring that professors should not focus on some of the smaller details over the larger concepts.

Other students felt that more practice was important to their level of understanding by stating the need for more hands-on activities in class, the addition of a lab period for the course to work on programs, having more line-by-line explanations of the code, giving more programming examples and more time to take notes during the class period, and giving more advanced students extra-credit opportunities to try

more challenging problems and concepts. One student also suggested that students should have unlimited tries on assignments until the student has mastered a topic, which relates to the foundation of competency-based learning. Parallel to the goal of this research and these programming courses, the students wish to have more time to gain an in-depth understanding of course material so that it can be understood, used, and applied in future programming.

eAsel Application Walkthrough Results

General Reactions to the eAsel Application

After going through the guided walkthrough of eAsel, students had different reactions towards the application. Eighteen of the students had only positive reactions, 12 students had both positive and negative comments, and 2 students were unsure of the effectiveness of the application.

Of the students who had positive comments about eAsel (as seen in Table 18), there were two main categories that students found important, which were the course structure and the course pacing. For the course structure, students liked how the course was broken down into smaller concepts that made the course easy to follow as they would progress through the competencies. Some commented that the structure seemed similar to Zybooks in how it shows the specific topics that were important to understand for each chapter. They also liked how there were a variety of activity types which students could complete to understand the different competencies. One student also felt that this application could help to have better synthesis between the different levels of programming courses, the different sections of the same course, and the different professors who taught these courses so that students were receiving similar sets of information.

Students that had positive comments on course pacing felt that they were better able to take their education into their own hands by being able to choose which activities would best suit their needs and

skip other ones that would not help them or that they already understood. Students also liked that they received more feedback on the different competencies so they knew where they were still struggling and that they could not move on to the next topic until they had mastered it. The application could also help them to find resources when they had questions about topics. Some students felt that it was difficult, at times, to find effective resources online by themselves. This instead could help them to have all of the information in one central location while also aggregating the information that exists on the other technologies that are available within the class like Canvas LMS and Zybooks.

Table 18. Positive Reactions Towards the eAsel Application.

Positive Reactions Towards eAsel	
Reactions	**Number of Students**
Course Pacing	30
Students can receive more feedback of where they are still struggling	6
Students can choose what works for them and take their education into their own hands	3
Students can skip topics they already understand	3
There are increased resources and activities	3
There is more individual attention with the professor	3
This application could fix the speed issues in the course	2
The application aggregates a lot of the resources into one spot	2
The application has a simple and friendly user interface	2
Professors can more easily see how students are preforming	2
Increased interactivity in the course	1
This application can help to solidify course knowledge	1
Students must master topics before moving onto the next ones	1
There is not grade associated with the 5-point rating scale	1
Course Structure	22
Breaks down the course topics well	11
eAsel is better than current technologies (e.g. Canvas LMS, Zybooks) and has more detail	3
Easy to follow course structure	3
Good activity options for students to use	3
The application creates a calendar through its course structure	1
Allows for better synthesis of the courses, sections, and professors	1

While there were a lot of positive comments towards eAsel, there were also some reservations that students had (Table 19). Some of these comments were that there could be information spread across too many technologies that the students will have to use within the classroom. The activities in the application could also be time consuming for students to complete. Others worried that the effectiveness of the application would depend on the professors using it. If the professor took a vested interest in the application and spent a lot of time and effort on the activities that were available to students as well as implementing the technology into the classroom it could be an effective tool; otherwise, it may go unused or be an extra tool that is not beneficial to students learning.

Many students questioned how the application would relate to student grades. One student said that if they were not required, many students would probably skip them, not complete them, or quickly click through them to show a completion without taking an effective amount of time to learn the material. Other students questioned how the activities and records would correlate with the students' grades within the course. For instance, did an A equate to a score of 5, a B was a score of 4, and so on?

Some students commented on the interface, stating that there needed to be more breaks between the different sections (i.e. objectives, competencies, and activities) to make the course easier to follow. Another student felt that it would help to make the activity links active so that they did not have to copy and paste the text between browser windows.

Table 19. Negative Reactions Towards the eAsel Application.

Negative Reactions Towards eAsel	
Reactions	**Number of Students**
The question of how these activities and assessments correlate with grading	5
The application could be time consuming	2
Success of the application would depend on the activities added by the professor and how the professor tailors the activities to the students	2
There will need to still be some time controls to make sure all competencies are completed by the end of the semester	2
The UI needs to have more breaks between the different sections/categories	2
There are too many technologies used within the classroom	1
There should be more feedback options in the Activity Record page	1
If the assignments are not required, students will not complete them	1
Professor might focus too much or too little on some students based on their progression through the course	1
Make the activity links active	1
Increase the size of the page and its components	1

eAsel's Ability to Affect Student Learning in the Classroom

After the guided walkthrough of eAsel, students were asked if they felt that it would affect students learning in the classroom. 23 of the students felt that it would positively affect student learning in the classroom (i.e., build the competency needed to succeed in programming coursework), 4 students felt that it might positively affect student learning, and 5 students felt that it could have both positive and negative effects within the classroom.

Of the students who felt that the application had the potential to help students learning in the classroom, 2 of those students said that the effectiveness depended on whether the application is properly implementation within the classroom. If it were, then, it would be beneficial.

Positive comments (seen in Table 20) that students had about the application were that students can complete activities that best help them without having to waste time with other activities that do not help them as well as give them more resources, examples, and practice problems to learn different

concepts in the classroom. Students also enjoyed that they are able to get more feedback on their current understanding of the different competencies within the course, which could ultimately motivate them to improve their scores as they move through the class.

Table 20. Positive Reactions to How eAsel Course Affect Student Learning.

Positive Reactions to Implementing eAsel into the Classroom	
Reactions	**Number of Students**
Students can move at their own pace and will not waste time with extra activities	8
Gives students a new platform with more options to learn	7
Gives students a central platform where students do not have to research on their own	7
More hands-on activities	6
eAsel seems like a better tool than Canvas	6
Students can base their learning on their own learning style	5
Students can't move on until mastery / deep learning acquired	5
Students can gain feedback on where they need to improve	4
There is a better course break down in eAsel than in the current structure	3
There are more group activities and interaction in the classroom	2
Students will be better motivated to reach a level 5 understand	2

While students had many positive comments, there were also some concerns that they had in relation to the effectiveness of student leaning while using eAsel. As seen in Table 21, students felt as though, if the application did not replace many of the other structures of the course, students might be overwhelmed by the amount of time and effort needed to complete the course. Also, one student felt as though it may be difficult for this application to be implemented in all classes because it would be difficult for a professor to interact with every one of the students. Another student felt that, if students are not regimented to learn the same activities, their understandings and education might be different and cause some students to have a harder time to learn if they are only using certain activities.

Table 21. Negative Reactions to How eAsel Could Affect Student Learning.

Negative Reactions to Implementing eAsel into the Classroom	
Reactions	**Number of Students**
There could be an increase in activity and time if it does not replace some of the activities in the current course structure	6
It will be difficult for the professor to interact with every student	1
If students are not required to complete certain activities, learning could be varied between each student	1
This type of application would be better for use outside the structured class time	1
Grading correlation to activities and assessments	1

Taking these two categories of comments together, one notes that the only negative reaction relating to the impact eAsel would have on learning directly was the asymmetry of students' knowledge-acquiring activities, which was expressed by only 1 of 32 students interviewed. Otherwise, students' negatives focused exclusively on implementation of eAsel in the classroom and course whether in relation to other educational activities or not. On the other hand, the positive reactions related to the direct impact eAsel (and, by extension, personalized learning) would have on attaining competency in programming coursework and skills and spoke explicitly of individualized educational pursuits' impacts on students' attainment in the College of IST's courses.

Student Opinions on Their Personal Usage of the Application

The students were also asked if they would want to use the application in the classroom. 24 students said that they would want to use the application, and 8 students said that they would possibly like to use the application. During this time, some students clarified when they would like to use the application. These reasons are seen in Table 22 and include if it allowed them to skip through sections they already understand, if competitiveness were assigned or required for the course, if they needed more resources or practice to help them understand the different objectives and competencies, and if those

resources were helpful to them. One student also felt that if the application was used within the class time, it would benefit them instead of just an out-of-class resource.

Table 22. Reasons Why Students Would Use eAsel

Reasons Why Students Would Use eAsel	
Reasons	**Number of Students**
If eAsel was assigned to the students	8
If the student needed more resources or help	2
If eAsel contained resources that benefited them	2
If students can skip through the modules they already understand	1
If the application was used during class time	1

There were several positive comments that the students gave as to why they could see themselves using the application if it were available within the classroom (Table 23). One comment that students said was that it looked like another application that they enjoyed using in the past. These applications include Zybooks and Pearlson's My Accounting Lab. Students also liked that the courses within the application had a clear breakdown of the course concepts, that they are able to access more practice for each of the concepts, and that it will help students with different levels of programming experience get help when learning Java. Importantly, all the reasons students cited as to why they would use eAsel to build programming competency related closely to personalized learning and individualized feedback within a programming-based educational process and experience.

Table 23. Positive Reasons Why the Students Would Use the Application.

Positive Reasons Why Students Would Use eAsel	
Reasons	**Number of Students**
Students can access more practice	8
There is a clear course structure and break down of concepts and resources	6
Students can learn by using their own preferred learning style	4
eAsel reminded the student of another application that helped them to learn	4
All of the class information is accessible in one spot without having to search for it on their own	3
There is more feedback available to students on their progress	3
The application seems different than any other tool available	1
Professors are able to see more feedback on student progress	1
Students have the ability to understand the concepts, not just the assignments	1
Students can move at their own pace	1
This supports students learning at different programming levels within the same course	1
This tool could help students review for job interviews	1
The application is easy to use	1

Some of the reactions were not as positive, and these are listed in Table 24. Some of these comments include that there would need to be a massive change in the structure of the programming courses to be able to effectively implement this application and that it would probably mostly benefit students in the introductory or lower level programming courses. Another student had concerns that the number of activities could cause added time to the students' already busy schedules with the classes, jobs, and activities that they are already involved in. One student also commented on the user interface of the application, stating that it looked archaic similar to the original LionPATH. A suggestion was to make it into a more modern and cleaner design similar to Zybooks.

Table 24. Negative Reasons Why the Students Would Not Use the Application

Negative Reasons Why Students Would Not Use eAsel	
Reasons	**Number of Students**
Group work may be difficult through the application	1
Massive changes are required to the current class structure	1
This would be beneficial for introductory courses only	1
The amount of benefit would depend on how much time the professor puts into the application and its resources	1
This application would only work in smaller sections of courses	1
The UI looks archaic	1
Students are busy and they would have to find more time to compete these activities	1

Chapter 6

Results of Instructor Interviews ad Guided Walkthroughs

Chapter Overview

This chapter examines the results of the interviews and guided walkthroughs with the instructors of the various programming courses offered in the College of IST. Specifically, this chapter discusses common themes collected from these interviews as well as the impressions and feedback instructors gave regarding eAsel.

These interviews were conducted during the spring 2019 semester, where 5 professors were interviewed about their programming courses and through a walkthrough of eAsel. The professors were recruited based on the courses that they have taught within the College of IST.

Professor Data

There were several professors that were interviewed for this research. These professors ranged from Assistant Teaching Professors of IST to Adjunct Faculty members to a PhD student who is a Graduate Teaching Fellow (Seen in Table 25). Together, these professors ranged from teaching experiences between 1 semester to 6 years in the College of IST. One professor had more experiences in China where he taught all levels of programming for various programming languages.

Table 25. Titles of Professor in the College of IST.

Professor Titles	
Position	**Number of Professors**
Adjunct Faculty member	3
Assistant Teaching Professor of IST	1
PhD student in a Graduate Teaching Fellow Position	1

These professors have taught a wide variety of the programming courses in the College of IST. These courses include IST 140, IST 210, IST 240, IST 242, IST 297I, IST 311, IST 411, IST 413, IST 555, DS 120, and DS 220.

Course Structure

Teaching Pedagogies

Each of the professors interviewed shared their teaching pedagogies for the courses that they teach. All of the professors interviewed said that their process of teaching depends on the class that is being taught and the individual course section of students. These pedagogies are shown in Table 26.

Table 26. Professor Teaching Pedagogies.

Teaching Pedagogies Used by IST Professors	
Teaching Pedagogies	**Number of Professors**
Program walkthroughs and/or white board demonstrations	5
Class activities and assignments	5
Class structure depended on the class	4
Co-production	2
Course lecture	2

One professor went as far as saying that he thinks that the classroom is as much of a learning experience for the students as it for the professors. Another stated that the class is a “co-production” in

which both the students and the instructors have to be equally engaged for the classroom to be an effective learning environment. Each semester is different and new situations arise that causes instructors to reform, modify, and improve their process for the students that they teach. To do this, one professor collects feedback from his students throughout the entire semester to learn where students need more guidance and how the classroom instruction should be set up to best help students learn. Although there are some restrictions on how the course can be set up, he likes to get this feedback to modify his own process to help these students.

The other professors employ a little more rigid process. A professor said that he includes a lecture section, but he tries to minimize this as much as possible because it does not hold student attention for long periods if they are being fed information from a PowerPoint. However, as another professor stated, PowerPoints are, at times, a necessary evil that have to be incorporated into the classroom to convey knowledge. To help mitigate this, the professor tries to make the class more engaging by interacting with the students to make them care about the class and topic.

This interaction comes from the programming walkthroughs. All of the professors that were interviewed said that they have implemented code walkthroughs into their courses. One professor said that he thinks that these walkthroughs help the students because it explains the code and there is a chance to learn other topics that are also important if a student is trying to learn to program. For instance, when there happens to be an error in the program (either planned or unplanned) the professor has the chance to teach the students how to use the debugger or give the students insights on how to determine where in the code an error occurred so that he can help them problem solve.

All of the professors also have some element of class activity that students are able to complete in the classroom. As one professor said, he tries to give students as much hands-on experience as possible and believes in an active learning environment. This professor guides students and takes a more constructivist approach, as students work through and learn class concepts through activities and group

work during the class time. Through this structure, two professors believe that students do not really understand a concept until they have done it themselves.

Although most of the professors had students complete coding assignments individually, one professor stated that he implemented paired programming in the classroom. In paired programming, one student writes the code (the driver) and one student says what should be written (the navigator) (Dick & Zarnett, 2002). During these sessions, the professor paired the students so that struggling students and higher preforming students were paired together. In this pairing, the struggling students acted as the drivers. This way, the students who were struggling were able to ask questions of the higher preforming students about why the code should be written a certain way.

Personalization within the Classroom

Professors also discussed personalization within the classroom. None of the professors have strict usage of personalization, but they each have used elements of it to better help individual students or class sections succeed in a course. These discussions are outlined in Table 27.

Table 27. Use of Personalization in the Classroom.

Personalization in the Classroom	
Personalization	**Number of Professors**
Personalization is not the focus, but some elements are used	5
Based on a per-student basis	2
Students complete personalized projects	2
Determined at a class-level to gauge where extra help is needed	1
Based on student types (distribution of a normal bell curve)	1
Provide extra, optional videos	1
Provides extra credit for advanced problems and concepts	1

Although none of the professors had implemented elements of the course with personalization in mind, one of the professors stated that he thinks he focuses on personalization at the class level rather

than for individual students. He does this by gauging where students are and determining if extra assistance is needed. This has been done by giving students a second chance on a quiz through a re-quiz. By doing this, he is able to re-review the material and allow students to ask questions about where they were struggling.

Two professors implement personalization based on a per-student basis. One professor said that if the students come and talk to him he can guide them through the curriculum in a way that will best help them, yet this is not done in most cases. The second bases personalization on students that participate through guidelines that are asked and practice completed in class.

Another professor feels that there is some personalization that is needed based on the level of success that each student has. In this professor's eyes, there are three types of students: the high-achieving students, the slower or struggling students, and the average students. Normally, the course is on a bell-curve where most students fall into the average category, and the advanced and struggling students are on each of the ends. Similar to competency-based learning, this professor realizes that each student must be taught differently that best helps them learn course material. Although there are three different groups, each of these groups have to be treated differently and given different attention so that they can succeed within the classroom.

Some smaller ways that these professors have implemented personalization within the classroom are by having extra videos available to students. These videos can be extra guidance related to the competencies being covered in class or similar, but related, topics in programming that help the student become a better programmer. One professor also gives extra-credit assignments to students who want to complete assignments that are considered challenging or cover material that have not yet been covered in the classroom. Another professor pulls together online resources for students who want extra guidance on topics. These online resources help these students understand the course competencies in different ways than were explained in the classroom.

Two professors also implemented projects that are personalized to the student or group. One of these class projects were personalized for their final in which each group had their own final project, where these students could work together in their groups to come up with a unique solution to their own project. Another professor completed different activities and class projects where he left the project to be more open-ended. When this happened, he was able to give these groups of students individual attention and feedback based on their specific submissions, questions, and comments. The more effort these students gave, the more feedback that this professor was able to give to these students.

Assessment of Competencies

After teaching students course concepts, each of the professors have different processes for assessing their students' level of competency both in their knowledge of course concepts and in the different didactics of the course.

Competencies Focused on in the Classroom

When determining what competencies were important within the classroom, four of the professors attempted to have a vocational outlook on the course structure. In doing so, these professors were forward-thinking in what the students would need for future classes and employment after college. All of these professors had experiences in the business world and knew what concepts were important for students to focus on. These professors brought their personal experience into the classroom to help students focus on the most important and beneficial pieces of logic to understand.

One professor focused on knowledge through conversations that were held between the instructors and students or the teaching assistants and students. Competencies were flexible based on the

level of the student and their own knowledge base within the course. The levels of competencies were based more on improved feedback on the at-student level.

Assessment of Students Accomplishing Course Competencies

Each professor had specific activity and assessment types that are used within the classroom to be able to measure the students' understanding of course concepts (seen in Table 28). Four of the professors used quizzes as a tool to gauge this understanding. These professors used procedural programming problems through the computer and IDE in these quizzes to test the students' knowledge. One professor, however, used written assessments where students had to write out the code or logic of a problem. His reason for doing this was because code frameworks sometimes had to be memorized. For instance, one of these written quizzes was for creating methods. When creating methods, there is a set number of words, names, and keywords that are used to create a new method. Students must have this memorized to fully understand what the code should look like, and what is needed to create a program.

Three professors discussed the labs and assignments that were used within the course. Two of these professors allowed students to complete in-class activities as well as an external assignment. The other professor had students create larger lab assignments that were one cohesive program that built onto itself as the semester progressed.

One professor also uses attendance to better understand the students in the course. The professor that uses this data said that students who do not attend the course as often are either those who are excelling and achieving high scores in the class or those who are completely struggling. The students who generally attend are the average students who are able to follow the course. The professor uses this attendance to be able to better understand the students when looking over and grading the course assignments.

Table 28. Assessment of Competencies.

Assessment of Competencies	
Assessments	**Number of Professors**
Quizzes (written and/or practical)	4
In-class activities and external lab assignments	3
Class attendance	1

Rubrics

Each of the professors had an opinion about rubrics (seen in Table 29). One of the professors said that they used rubrics and were very ridged towards the grading associated to the rubric. This professor did not often deviate from the elements that were present within these guided items. A second professor said that he too used rubrics, but kept it more general and did not have specific breakdowns of items that had to be completed. Both of these professors were less worried about the finer points and redundant information, but they wanted to know if the students understood the overarching ideas, logic, and background knowledge for that concept. One of these professors stated that they cared more about the concepts instead of its details. However, if the students were able to figure out something similar, they would not always mark the student down as low as a student who had little to no concept of the needed data.

Table 29. Rubric-Based Assessments Used in Application Development Courses.

Rubric-Based Assessments	
Rubric Styles	**Number of Professors**
Create rubrics to capture logic and background knowledge over small coding details	2
Professors felt that students can abuse rubrics to achieve higher grades	2
Follow a ridged grading rubric	1
Used a generalized rubric	1
Added subjective categories to rubrics for “gray” areas of code	1
The professor does not believe rubrics are an effective grading tool	1
Grading was completed on a case-by-case basis	1

Two professors had a contrary opinion towards rubrics. One of these professors said that he still used a rubric for course assignments, but felt that rubrics were often too formulaic, when there were some subjective elements to assignments. To fix this, a professor left some of the rubric to have subjectivity as well to be able to grade around these gray areas. Other areas that he focused on in the rubric were if the code was readable, if the program did what it was supposed to, if there was reasonable decomposition of the problem and sound logic, and if the code was commented appropriately. The other professor does not use or believe that rubrics are an effective tool for measuring understanding. He instead gave feedback to the students and wanted the students to know that the grading and feedback were not punishments, but helpful comments to improve their code, process, and knowledge for future assignments. Both of the professors who went back and forth over the use of rubrics felt that students could complete assignments based on the guidelines in the rubric and receive a grade that was higher than actually deserved.

Another professor had a generic rubric that he used. For instance, this rubric questioned whether the program worked, whether the program ran, if there was redundant code, and if it looked like the student understood that problem and how to solve it. By looking at the program, the professors had an idea of the student's level of understanding of the concept. In this, the rubric serves more of a checklist of items to look for rather than specific pieces that are required in the code. Because of this, the grading is done on a case-by-case basis.

Feedback of Student Competency of Course Concepts

Sometimes, after the completion of an assignment or quiz, students did not always preform as well as expected. When this happened, the professors would try to help guide these students to getting improved scores. At the individual level, 3 of the professors said that they or the course assistant will reach out to these students to see where they are and where they are struggling.

However, as two professors discussed, when the lack of understanding is common across the entire course, the professor needs to take action. These problems could be the result of many issues. For instance, a concept might not have been taught as clearly as intended, the professor could have changed how they taught the material in previous semesters, and it could also be the students who may have different prior experiences or external factors that made it difficult to learn a concept. When this happens, the professors said that they take it upon themselves to re-teach or review the information to help these students. One professor said that they sometimes re-quiz the students so that they have more time to learn and understand the concepts and fill in the gaps that were present during the first quiz.

Another professor collects feedback from the students throughout the semester. This feedback includes data on how to improve the structure of the course and helps identify concepts that students are struggling to understand. By doing this, the professor is able to see if there are consistent themes of knowledge gaps that would help the entire class improve within the course.

Challenges within the Classroom

The interviewed professors have noticed different challenges within the classroom over their teaching career. These challenges involve the students taking the course, time constraints to learn the content, and course structure. As one professor stated, these challenge change from semester-to-semester. Every year, a professor identifies new challenges and tries to solve them as best as possible.

Students Taking Programming Courses

There are many challenges encountered by the students taking the programming courses offered by the college (seen in Table 30). There are the in-class behavioral issues such as talking; however, many of the challenges come from the previous experiences of the students and what they hope to gain out of

the class. Three professors discussed that difficulties arise when students in the classroom have different previous experiences, such as with the programming language or with other subjects that help when learning programming, such as mathematical concepts. The question becomes, how do you teach a course that engages and challenges students who have previous knowledge, while helping the students who are new or struggling with various elements and concepts in the course? Making one cohesive class that tends to all students with varying skillsets while keeping the same set of standards for each of these types of students can almost be a job in itself. One professor discussed that he tried to accomplish this by focusing on the average or mid-tier students. Some of the upper and lower level students may get lost in this process, but giving these upper and lower groups some different instances of attention to help them stay on track in the class can fix this. Another professor said that he tried to have a sidebar with these students by talking to them about their inquires after class or individually during work sessions. Because class time is limited, he did not want to take time away from students trying to learn the material needed for class assignments and understanding foundational knowledge. This challenge mimics one of the issues that are accounted for with competency-based learning. In this framework, all students start at the same level of knowledge and are required to take pre-requisite classes if they do not have a background in a certain subject.

A similar challenge to this is the ability to motivate students to learn and achieve at higher levels. As this professor said, it is easy to assess if a student understands the program that they have completed by looking at the code. Because the professor has been programming for several decades, it is easy to look at the submitted code to understand if they understood the material. However, after this assessment, it can be difficult to motivate these students to improve their score or to care about the topics that are being taught. To overcome this, the professor started to discuss the concepts in terms that are real-world or applicable situations. For instance, in IST 210, when creating databases, he used the North Star database data to ask real questions about the data, how to manipulate it, and how to use it. This allows students to

see the reasons behind course topics, rather than just seeing small modular assignments that do not give students the full picture of the capabilities of the code they are writing.

Another challenge with students is their end goal of the course. Some students take programming classes because they are generally interested in learning to program or are in the IST Design and Development option which focuses on application development; however, other students are taking these courses because they are required by other majors or minors that are not necessarily focused on programming. Teaching the course so that it engages each of these types of students can be a difficult task because they each have different end trajectories for their academic careers.

One professor also discussed the differences between cultures and between different students. Although students in the United States are more outspoken than students in other countries, like China, there are still some students who have a difficult time communicating with the professor about their struggles in the course. This can make it difficult for the professors to get a full understanding of where students are in the course.

Table 30. Instructor Challenges with Students Taking Application Development Courses.

Challenges with Students	
Student Challenges	**Number of Professors**
Varied prior knowledge	3
Motivating students to improve	1
Cultural differences between American and foreign students	1

Time

There were 4 professors who felt that they had to keep the course at a certain pace (seen in Table 31). Three professors felt that there were time constraints that made it difficult for students to learn. A fourth professors felt that he had to remember to slow the course down so that the students had adequate time to learn. Because it was his first semester teaching the course, he felt that he had to adjust to teaching

students who were new to the language. Although many of the concepts came easily to him because of his twenty or more years of experience, this was not the case with his students.

Table 31. Challenges with Time in Application Development Classrooms.

Challenges with Time	
Time Challenges	**Number of Professors**
Java's steep learning curve	3
The professor had to slow down to match the learners' pace	1
Overcoming external factors outside of programming	1
Students need for more practice time	1

For the 3 professors who felt that there were time constraints, these professors felt that there was a steep learning curve to programming, especially when learning the Java language. These professors agreed that there was a lot of information that the students had to be able to understand; however, they took two different stances on why students struggle with this vast amount of information.

One professor felt that, along with the language itself, there were a lot of other factors that also create difficulty for students. Outside of the programming language, there is a lot of other learning that students have to do. For instance, students have to learn how to use the NetBeans IDE, use the school computers that are available within the classroom, learn pre-requisite information about programming (for instance, information about how a computer works), how to properly submit class files, and more that all add onto learning the actual programming aspect. These factors, especially in the beginning of the semester, can add several levels of complexity to the contents of the course. This can especially be the case in the beginning of the semester. Although the course material generally starts off slow in the beginning units, the added outside complexities can make this short time period even more difficult to navigate.

Another professor felt that students not only have to learn, but they have to learn how to learn programming. The students need to spend an adequate amount of time programming, both in and out of the classroom. This can be accomplished by practicing outside of the class period. The more students

practice and get in the habit of practicing, the more they will be able to learn about the language and it will help them understand programming. One barrier of this, however, is that students do not always know what they need to know, or how to find the information, which creates challenges when students are taking a lot of time and effort to learn the material on top of trying to find quality resources.

Course Structure

The last challenge is the structure of the programming courses that students have to take (seen in Table 32). One professor felt that, at times, there may be a mis-match between the logical order that makes sense to an instructor, and the logical order that makes sense to a student. Because of their different experience levels, and the different points of view that the two groups share, this can cause a rift between how students learn and how instructors teach.

Table 32. Challenges with the Course Structure in Application Development Courses.

Course Structure Challenges	
Course Structure Challenges	**Number of Professors**
Filling in Knowledge gaps for students without prior knowledge	2
Mis-match between the logical order for students and instructors	1
Student performance is affected by changing the structure	1

This disconnect relative to the course order is a concern to professors. Two professors discussed how students within the same class may have two different sets of background knowledge. Within the same class, students might have different sets of background knowledge based on the professors that they had in pre-requisite courses. This can cause professors of intermediate and upper levels courses to determine where those knowledge bases are so that they can fill in these gaps.

One professor said that this could also be the cause of changing how a unit is taught or changing the order in which some units are taught. Within his own class, he noticed that students sometimes had a

difficult time with a unit that had not been a problem for any of his prior semesters. However, that semester he had revamped the order of two units and some of the lecture material that was used during the class sessions, which may have changed the level of student comprehension.

eAsel Application Walkthrough Results

Just like the student interviews, the instructors also completed a walkthrough of eAsel. From this guided walkthrough, the instructors' reactions to the application were recorded along with their opinions of its implications within the classroom.

Reactions Towards the eAsel Application

Positives

Four of the professors had positive comments towards the application, and two of the professors commented that they thought the application was impressive. These results are displayed in Table 33. Of the reactions, there were several aspects of focus. One positive comment was that this would give students a number of new supplemental resources to use throughout the course allowing them to choose to use these activities, or not, based on their needs. These additional resources would allow for individual student achievement of the various course concepts.

Table 33. Instructors' Positive Comments about eAsel.

Positive Comments about eAsel	
Comments	**Number of Professors**
Students are given more supplemental resources	2
More detailed course structure than Canvas	2
Flexible activities with ridged assessments	1
Professors can more closely monitor students	1
eAsel can represent a live syllabus	1

Another example of the positive aspects was on the assignments and assessments within the course. One professor commented that he liked how the activities were flexible and could be chosen by the students, but that the assessments were ridged and had to be taken by every student in the course to so that they could be certified in a competency. By having this, students have the flexibility of choosing how they learn, but there is a single set method to assess the students' competencies within the classroom.

Another professor focused on the activities and records, but mentioned the professor's ability to better monitor the students in the classroom. By seeing the activities and the activity records, the professor is better able to gauge what students are using within the course and how well they are working through the modules as well as feedback on the performance of the professor. By having this, it not only allows the professor to see how well the students are doing, but it also gives feedback to the professor to see if they need to adjust their individual teaching, the course structure, or other aspects that could be hindering the students' ability to learn. Professors can also use these results to better target different groups of students earlier in the course that may be struggling or excelling.

A final positive focus area of these professors was the structuring of the course. One professor went as far as to say that the application was a better, more detailed version of the Canvas LMS syllabus feature. Another professor said that although the structure was similar to Canvas LMS, eAsel allowed for an extra layer of course breakdown. By having courses structured in the format that eAsel allows, more details of the course can be realized. The assignments and instructor's lessons can work from this application, as an almost live version of the syllabus. The assignments within the course can help to meet

the different learning goals within the course as well as learn them. Another professor discussed that assignments in this application can replace all of the other major course assignments that are generally present within these programming courses.

Negatives

Along with the positive comments, there were also some concerns that were given by the instructors to think about before the implementation of this application into the classroom (seen in Table 34). The first comment is that students will need to be motivated to use this application. If students are not given rewards, or convinced that the application is a worthwhile experience, they will not use or take an interest in the application. Another aspect of concerns is to restrict students from attempting the assessment before understanding the concepts. As one professor discussed, if the assessments and activities are open, the students will want to try the assessment first to see what they need to learn and what is being assessed before spending the adequate amount of time learning the material.

The last comment is that this application's effectiveness can depend on the class size. It was mentioned that a larger class size would make it harder to interact with students on an individual level, especially if the professor plans to get to know the students so that they can effectively assess their knowledge of the course concepts.

Table 34. Instructors' Negative Comments about eAsel.

Negative Comments about eAsel	
Comments	**Number of Professors**
If students are not motivated to use the application, they will not use it	1
Class size can vary effectiveness	1
Students can attempt assessments before learning the competencies	1

Important Features to Consider

When discussing the application with the professors, they discussed different features that would need to be implemented so that it could be used within the classroom (seen in Table 35). One feature that all of the professors commented on is the integration of other course tools into the system. For instance, currently, course masters and instructors must enter student names by hand. This, however, can be tedious, is prone to error, and can be very time consuming. For professors who have seventy-five students in a single section of a course and teach multiple sections, this could be a lot of work at the beginning of the semester. To fix this, they suggested that it be integrated with tools such as Canvas LMS or Excel so that the data can be passed between applications. This integration could also be beneficial for entering student grades based on activities that were completed and other grades that students received in any of the classroom tools.

Table 35. Features to Consider in eAsel.

Possible Features to Implement in eAsel	
Features	**Number of Professors**
Integration of Penn State Authentication and Canvas	5
Data analytics of student data to improve the course	3
Pre-assessment of competencies by students	1
Repository of data to share between professors	1

Another area of concern discussed were changes to the user interface (seen in Table 36). This includes creating active links for the different activities in the activity description so that students do not need to cut and paste the link in their browser. Another suggested upgrade was to break up the objectives, competencies, and activities using larger or bolded headers that would more easily separate the different sections of the course. By doing so, it will make the user interface a little easier to follow. Similar to this a professor felt that the tool could be more intuitive. If this were the case, there would be less need to train students and other professors in the tool.

Table 36. Suggested User Interface Changes in eAsel.

Possible User Interface Changes	
User Interface Changes	**Number of Professors**
Automated grading of assignments	2
Adding active links in activity summaries	1
Using an embedded text editor (i.e. JSFiddle)	1
Clearer divisions between objectives, competencies, and activities	1
Defined ordering of activities and assessments	1
Move the activity record link into the same box as the assessment	1
Create a more intuitive design	1

Along with this, the activities could be ordered by category so that they are more easily identified. One professor also stated that it would be important to have proper ordering of the activities within the competencies. For instance, the assessments should always be placed at the bottom of the list, because theoretically this should be the last activity completed by students. This professor also felt that the activity record page should be accessed through the individual assessments instead of having a generic entry page at the top of the assignment. This will make it easier to enter multiple students at one time.

For the activities that are used within eAsel, one professor suggested more capabilities in the activities. For instance, the implementation of code editor would allow students to stay within the application while completing work. So that students do not always have to use NetBeans when competing tasks. This could be similar to Zybooks, which guides students through a problem. There are several online editors available that can be embedded into the tool. An example of this is a JavaScript editor, JSFiddle (JSFiddle, 2019).

One professor also focused on the activities and assessments, including their criteria to allow students to assess their own potential certification for different competencies. Specifically, the criteria for these activities and their types can be subjective. Because of this, the professor felt that it would be beneficial to have more criteria that defines these activities. These guidelines could be created and formalized for the different professors teaching these classes. There may even be a potential need for a repository or shared area for different materials that different professors have used for these courses. By

having clarity on these criteria factors, it would create an easier time for professors and teaching assistants when attempting to score students in these various areas of the course.

When it comes time to assess these students on their knowledge, there can be different scoring features added to the application. There were two professors that discussed scoring features. For instance, students could have the ability to pre-score themselves on their knowledge of the concept before the professor does the official assessment. This will give the student an idea of their level of knowledge before meeting with the professor or class assistants. A second professor suggested the implementation of an auto grader for coding programs and other assignments. There are several auto-grading systems available today.

Data analytics was also an important feature for three of the professors. By having more data analytics, the professors would be able to better understand how to improve their course, determine which students were devoting extra effort to understand the material, how effective the material is for students, what activities the students are using, how students improved in specific competencies, and the ability to debug the course structure. There could also be analytics to understand the different types of students taking the courses, such as students that are from other campuses and students who had different professors.

Application of eAsel within the Classroom

After completing the guided walkthrough of the eAsel application, the professors were asked about the application of eAsel within the classroom, specifically if they thought that would be a positively affect tool for student learning in the classroom.

The Effect of eAsel within the Classroom

During the interviews, two professors said that the application would be beneficial to students learning within the classroom, and one of the professors said that it was possible that this application could be beneficial to students (but they were not sure how), a fourth professor said that there needs be more definitions on some aspects of the course structure before it would become effective, and the last professor envisions a class structure similar to the current one.

All of the professors discussed the ramifications of the application in regards to the course structure (seen in Table 37). Two professors were concerned with the amount of time that it would take just to prepare the application for the semester. One professor said that this tool could create more administrative work, both at the beginning and throughout the semester. As for an adjunct teacher, these instructors do not always have as much time to dedicate to the creation of these classes, so lessons can be created and edited week-to-week. With using this application, it could create more impediments to prepare both the application and the lesson plans for each week.

Table 37. Explanations of Ramifications for Implementing eAsel into the Classroom.

Implementing eAsel into the Classroom	
Explanations	**Number of Professors**
Increased time for course preparations at the beginning of the semester	2
eAsel might work better as an external activity because of limited time	2
Several course structure questions still need to be answered	2
Instructors and teaching assistants will have to adjust to varied activities	1
eAsel might work better as a course designing tool	1
eAsel adds another layer of complexity to the course	1

Along with the course structure, time is limited within the classroom, which could create difficulties when trying to fit in time to move through the modules in class. Because of this, it may help to have students use the application outside of the course period and reward them for doing so on their own time. But, looking at the structure of these classes as a whole, the implementation of eAsel may spark

some conversations on how to change the structure of the course that models what is expected by both the professors and students.

On top of this, there would be an increased amount of work for the instructors and supporting assistants within the course. As one professor discussed, during a class period, the instructor and learning assistants walk around the room answering student questions and helping students as needed. This is generally easy because students are working on the same assignments with a set number of problems and questions to which the instructors and assistants can prepare for; however, this would not be the case with eAsel. Since students can be working on a wide variety of activities and lessons during a normal class period through eAsel, it will create a more difficult time for these course staff members who have to perform multiple duties and roles as they move between students working on varied pieces of information. Similar to this, by adding another tool there is not only complexity for professors, but there is added complexity for the students taking these courses there will now be another tool and another layer to the course that students will have to use and overcome to learn course concepts.

The professor who was not sure how eAsel could be implemented in the course felt that eAsel may be better served for the instructors teaching the courses. This application could be a tool professors are able to use when designing their courses. By breaking the course down into specific objectives and competencies, the instructor will be able to determine the ‘why’ and ‘how’ for each competency and activity and how it serves as an important piece for the students to be able to learn programming within the course.

The professor who mentioned there were course structure requirements that still needed to be determined before the application could be effective in the classroom discussed his concern about the structure of taking and re-taking assessments to gain mastery. This can be difficult with the limited time for the class and availability of the professors. As this professor said, the professors have to worry about many aspects of the course that are outside of teaching and learning, including motivation and policing. Grading is one of the aspects of the class that takes the most amount of time and can be very involved,

which may make it difficult to accomplish in a short amount of time as well as multiple times for each student. Because of this, restrictions should be made to the course when looking at assessments, including a limited number of attempts to 2 or 3 tries, or use an automated testing harness that grades some of the assessments automatically. If not structured properly, this could add time and work to the instructor's daily and weekly responsibilities.

Another question was how do students improve their scores if they do not reach a level of mastery on the competency. Does the student go back to the materials that are already provided to them or are they given supplemental resources that focus on specific places where they had difficulties? On top of this, if the assessments are the same for each re-test the student will learn to the material that they know they are required to complete. Instead, there should be multiple assessments that are used.

Similar to this, there were also concerns about the course structure. Specifically, if this tool would replace assignments that are currently within the course. In addition, how could these assignments be more customized to these students' individual needs?

These two professors felt more guidance was necessary on how the tool would be implemented. The tool seems more high-level in is current state, but if it is meant to replace tools, eAsel must be marketed to help professors and students with different capabilities that are not currently available in tools already used in these classrooms.

Likelihood of using eAsel in the Classroom

When it comes to the likelihood of using the application within the classroom, one professor said that they would, two professors said that they might use eAsel, one professor said that they would depending on how some of the course structuring was outlined to better fit a semester course, and one professor said that he would not use the tool because he likes the current course structure. Along with these responses, the professors added on their reasoning.

One of the stipulations was the integration of Canvas LMS that was stated earlier. Another comment was how the scoring correlated with the student grades. As this is a question that students often ask, this is an important consideration when thinking about the actual implementation of the tool. The final comment was the overhead work from week-to-week that was discussed in the previous section. The amount of overhead work required could make it difficult to have adequate preparation and available activities of the unit for students.

The professor that questioned the course structure said that there needed to be more thought about how instructors would use this application. Currently, the application is structured around the students to help them move through the course and better understand concepts; however, there was still some variability with the instructor side that needed to be determined before it could be an effective tool. These determinations would need to help cut down on the amount of work for the professor instead of add to it.

Chapter 7

Results of Student Learning Observations

Chapter Overview

This chapter examines the results for the student learning observations during a programming course and College tutoring sessions. Specifically, this chapter discusses the records that were entered into the activity record page in eAsel that scores students' knowledge of the course concepts based on the observations conducted within a course and during tutoring sessions as well as the process of using this feature to enter data into eAsel.

Observation and Student Scoring of Understanding

Throughout the spring 2019 semester, the researcher worked in a section of the IST 242 that teaches object-oriented Java programming to students as well as during tutoring sessions hosted by the College of IST. During this time, the researcher was able to interact with many different students and enter activity records for a total of 63 students. Specifically, 48 were recorded for students in the IST 242 section and 15 students were recorded during the tutoring sessions.

Each of these records took approximately one minute or less to complete and were simple and easy to fill out. The form had a simple layout that was straightforward and was easy to complete. The activity that the student was being assessed on was easy to find through the dropdowns that filtered the activities first by their objectives, then competencies, followed by the assessment activity. The shorter lists of activities that the researcher had to search through made it quick to access the activities that were

being used. The feedback section took the longest to complete because the length of the feedback would vary depending on the activity being completed and the student's performance. This was the most difficult section to complete because the researcher had to describe what the students did, how they completed the activity, how the students could improve (if at all), and why they received the score that they did.

Some difficulties that arose while completing the form were with the feedback section. In this section, there is just a single box of text for the professor or teaching assistant to complete. This can make it difficult to give a detailed enough description that encompasses all of the pieces of data that would help the student to review and understand how to improve. This is especially difficult if the students are completing activities that may have multiple sub-components that have to be completed. Because of this, it would be beneficial to build up this section to split it up into different sections. This could have several different looks.

One way is that the professor can add a list of feedback requirements for an assessment that the student has to complete for a specific competency. In the activity record page, these requirements could be checkboxes that would be selected or separate text areas where the professor can enter data.

Another difficulty with adding activity records is that even though this may not take a lot of time, it can be hard to enter the data when a lot of students are looking for help from the professor or teaching assistants within the classroom. On a busy day in a classroom, as soon as a professor or assistant stands up after helping a student there are already several hands in the air looking for help. This can make it difficult to spend more time entering data when there are other students that have to be helped during a class period, which may only be 50 minutes in duration.

Chapter 8

Discussion

Chapter Overview

This chapter tries to understand why the results presented in the previous chapters for each of the areas of data collection may exist. Between the instructor and student interviews there were several commonalities between challenges faced throughout these semester long courses. Some of these ideas also blended into the experiences found when entering student data into eAsel's activity record pages.

When looking at the student learning observations and interviews with students and instructors there are sections devoted to both the benefits and challenges associated with implementing eAsel into various programming courses. These areas range from the tool itself, adoption of the tool by the students and instructors, and finally to the structure of the different courses. By understanding these potential ways to implement the tool and what aspects still need to be considered to make the tool effective in the classroom, the ability of implementing eAsel into the classroom as a tool for both students and staff is better realized.

Breakdown of the Course Structure

A consistent theme found throughout the interviews and student activity records is the idea of breaking the course down into smaller, more manageable parts because of a three-tiered hierarchy that looks at the larger picture, sub-picture, and finally individual modular activities that students can

complete to understand a concept. As one professor stated, with eAsel, there is an extra level of breakdown that is not accessible within other tools in the classroom, such as Canvas LMS.

Both students and instructors felt that this course framework could benefit both students and instructors during the semester. For students, this could help to better understand the flow of the course, identify where they were within the course, what competencies had been accomplished, and what competencies still needed to be accomplished before completion of the course. For instructors, the course design could be a tool that helped to better design the courses with both the instructors and students in mind. One professor discussed that eAsel could be a beneficial tool when designing courses. By using eAsel, the professors can better understand which aspects of the course are needed, why they are important to the students, and provide an understanding of the tools that are given to these students to learn a specific concept.

Adding Resources for Students to Use

A common issue discussed during student interviews was the number of available resources. Many students felt that they needed more examples, code walkthroughs, and practice activities to really understand different coding concepts. Both students and professors also discussed that it can be difficult for students to find information on their own. For instance, one student felt that he was spending an enormous amount of time trying to find resources and information to learn and understand the material. Some students do not know what to search for or know if the information that they had found was worth-while to their learning experience. One professor said that it is important to give students at least a little leeway, as not just to leave them hanging alone when they seek to understand course material. Students must at least have a little bit of a guide so that they can continue to learn and not get stuck or left behind.

Because of this, eAsel can give students the resources they need that will benefit their learning experience. By having a larger volume of resources available, these students will be able to use their time

learning material rather than finding it. They will also be able to pick resources that can fill in the gaps to their understanding. For instance, completing more practice examples or gaining a greater understanding of the theory behind a concept through readings and videos. Students will know that the information that they are learning is correct and worthwhile because it was vetted and added to the website by their professor, so they will not have to question its validity or relevance. At the same time, they will be able to know where in the concept they need to continue learning, whether it be more hands-on activities, or theory-based data for a concept.

By having the availability to add different types of resources, and break those resources down by type for the different learning competencies, instructors can see where students are struggling in the course and where students need more resources to better learn different competencies within the course. By using the course structure in eAsel, professors can see where there may be a lack of materials and resources for students in the different competencies in the course. They can also use the records as feedback, professors can easily see where more resources are required for students to more easily understand some of the course concepts that they may be struggling to understand. This feedback can show what types of activities the students require to score better in these areas. This is not necessarily a straight answer for each concept, and can depend on the course, the concept, and the semester of students. However, the professors will be able to have more feedback on what the students are struggling with for each competency and be able to provide them with more information that can help them to achieve higher scores whether that be more hands-on activities, or theory-based information.

Along with this, students will be better able to pin-point specific activities that they can use to review because of the structure of the competencies that the students have completed. When students need a refresher on passed competencies, or as one student said, when there is a need to review material for an interview with a potential employer, these students will have an easier time finding materials that will give them the best refresher of a specific concept they are looking to use or understand.

Throughout the researcher's interactions with students in completing her study, the interviewees consistently approved of personalized-learning approaches, particularly those represented by eAsel during the guided walkthrough. Students' concerns with eAsel did not lie with the individualized experience available (aside from the 1 student who was concerned about the differing combinations of tasks students would utilize in building knowledge), but with the manner in which faculty would implement eAsel and personalized learning in general into a course's framework in a consistent, impactful way. Almost all students replied positively when asked *whether* they would use eAsel, providing a long list of advantages explaining *why* they would do so, and this speaks volumes about the potential benefits using or expanding eAsel and other modes of personalized learning would have in building programming competency in the College of IST's courses.

Filling Gaps in Knowledge

Competency-based and personalized learning, as represented by eAsel, can help students and instructors have a more consistent and overlapped understanding of the knowledge that is required for student understand and identify what knowledge the students already have from previous units, courses, and outside experiences. One theme that was consistent with both instructors and students was the miss-match between what knowledge the students had and what knowledge the instructors expected these students had when coming into the course or while learning various concepts throughout the semester. These assumptions may be determined for a combination of reasons including the assumption of what other professors had taught in preceding courses, what knowledge that students should already know from other outside life experiences, lack of retention of the knowledge that was taught in previous courses, and the fact that professors have had several more years (or decades) of experience with the material making it more of a second-hand nature for themselves but not for the students they are teaching.

One student said she wished instructors did not have an assumed level of student knowledge before coming into the course. When this happened, it made learning the concepts more difficult because more outside work was required to learn these concepts they were already expected to understand on top of the time that it took to understand the new concepts being taught within the course.

By using eAsel, this problem could be better mitigated because it will allow instructors to better understand where some of these gaps in the curriculum are located by measuring and analyzing feedback acquired through testing student competencies for each course concept. By filling these gaps with more activities, resources, and guidance, students might have an easier time staying on track in the course and learning the concepts that they may not have previously encountered or had a deep level of understanding with previous interactions.

Creating a More Consistent Course Structure between All Courses

Similar to what was stated earlier, the students within a single class could have different previous learning experiences based on the courses that they have taken, professors that have taught their courses, campuses that they attended, previous life-experiences outside of the classroom, and many more circumstances.

Because of these different experiences, teaching students within one section of the course can be difficult. eAsel can be a way to help mitigate these differences by creating a more universal structure by outlining concepts and materials in the same or similar format at all levels of the curriculum, creating consistent data flows of material between courses, and helping professors better understand what students have learned within their previous courses and what competencies the students need to achieve before moving onto the next level of programming.

One way to do this, is to provide a more consistent course structure between the different courses and the various sections of each course. Although there are tools on Canvas LMS which allow this

through their Modules, Assignment, Syllabus, and Files pages, each professor uses these structures in different ways. This can make it difficult for students to find information between courses when each professor places their course information in different locations on the same site. eAsel can fix this through its streamlined view of the different objectives, competencies, and activities. Everything is located on the same page and is organized based on the competencies and objectives for the course. Because there is a more defined structure on how the course and course resources are laid out, students will have an easier time adapting to the new courses they are taking from semester to semester. They will no longer have to figure out how each of their professors are using the various features to display information across the site.

Instructors can also communicate and share their courses with other professors to see what information was taught in the various courses and sections. With the breakdown of relevant and necessary course topics that should be accomplished during a semester, the instructors will be able to better compare what experiences their students have had. This will enable these professors to be able to know how much information each of their students already have when entering the course so as to not assume that the students have more or less knowledge than needed to complete the various activities and assignments given in the course.

Using eAsel in Combination with Other Course Structures

Although there are several foreseeable benefits to the course framework offered through eAsel, there are also some possible challenges that can occur. These changes are related to using eAsel in tandem with other course structures present in the educational system, including course lectures and the resource management tool Canvas LMS. By using this in combination with the regular course lecture, students may not see how beneficial eAsel can be as a resource to their overall learning as it could be seen as another task that they have to complete on the way to earning their course grade.

Another challenge could be the amount of resources, and locations of those resources that students will have to navigate while they are attempting to learn course concepts. At Penn State, the predominant resource management tool is Canvas LMS, where professors provide several links to beneficial materials. By having information spread across both technologies, the students may find it difficult to easily pin-point the location of a specific resource they need. Also, although Canvas LMS does not have the monitoring capability that eAsel does, requiring the students to use both Canvas LMS and eAsel to access resources and monitor their progress would require educating the students as to the benefits of both systems and how they both help the students to learn.

Balancing the Size of a Competency

One challenge of re-structuring a course for eAsel is to understand how far to break down each section to best suit the needs of the course, the students, and the teaching staff within the course. Although currently many courses look at knowledge and learning at the objective level, breaking down these objectives into smaller pieces can be tricky. For instance, one issue is not breaking down the objective far enough, which ultimately ends in creating a competency that contains a lot of different types of course material. By having a competency that has a lot of moving parts, it can be difficult to truly gauge the level of a student's understanding because multiple aspects of the course are being measured.

One example of this is breaking down looping, and keeping all of the loops within the same competency. Although this does not seem problematic at first, because there are other competencies within this same objective to understand (including nesting loops, enhanced versions of the loops, and common algorithms and actions that loops can create such as re-ordering values) there could be a problem with creating a large competency in comparison to the others in the same objective as well as the volume of data and learning that is involved in comparison to the other competencies in this same section.

At the same time, however, there is the opposite problem, which is breaking down the objective to have extremely tiny competencies, creating a large number of competencies with little course material and learning required. In the same context as the earlier example, this could be breaking down the competencies so that each competency describes different parts of the loop, for instance, the condition statement. At times a course designer may struggle between what sections are too large and what sections are too small. This will most-likely vary from class to class and course designer to course designer.

Overlapping Learning Sub-Type Materials

A second challenge in creating and using material in this application is when the material overlaps in more than one of the learning type and sub-type groups. When this happens, there are several responses to remedy the situation. The first is to completely remove this piece of material and create or find a new version that fits this category. A second option is to list this course material under the learning type where it is more predominantly evident for the item. Another choice is to list this information multiple times under all of the categories that it fits into. Finally, although the system does not currently handle this, eAsel may benefit from an option to multi-list a piece of media that has more than one form of learning associated with it. This may depend on the needs of the course and how it is structured within eAsel, but the application may benefit from some added functionality in this area for any future studies that are conducted.

Variability within Tutoring Session Learning

Tutoring sessions as a whole are a varied experience for both the tutor and the student; therefore, making a course that works in a tutoring setting can be extremely difficulty to sufficiently cover all of the possible needs of the student and gauge their level of competency for material they are currently covering.

Each session can be dramatically different from the previous and it may be difficult to encompass all of the necessary materials needed to make each interaction between tutor and student a meaningful and positive one. For instance, if a student has a very specific question about a certain topic, that information may not be covered within the general material given within the competencies that have already been created.

Self-guided material may not provide a positive learning environment for all students. For instance, videos may not be helpful to a student who is attending a tutoring session and expecting a face-to-face conversation about a specific course topic where they were looking for clarification.

Course Pacing

The speed of the programming courses in the College of IST was a common theme throughout many of the interviews. During these interviews, both the professors and many of the students agreed that a lot of information is covered in a short time frame, making these courses feel fast-paced. There were many reasons for this, including a lack of deep learning of the material that was covered, an enormous amount of material that had to be learned for each unit, external factors about the classroom environment that students had to overcome, preceding or external knowledge that students needed to understand before programming, and many more constraints.

Many students were excited by the fact that there were some requirements of levels of achievement before being able to move onto the next competencies or objective within the course. Students were excited because they could take more time on areas that had confused them to ensure they understood the material before moving on. This allows for the ability to acquire deeper learning of the course material instead of rushing through and only understanding an item at the surface level with enough knowledge to get by for an assignment or quiz. If a deeper level of understanding was acquired, these students would not need to refresh themselves on previous course concepts when looking to use

them in later units because they would have a better grasp on where they were the in the course and the material leading to their current point because they are required to master the preceding topics before moving on to another competency.

However, with this there can also be some challenges within the classroom. In a truly personalized course, students would be able to move through the course at their own speed. In many personalized learning environments discussed earlier, the learner is able to control the speed at which they move through the course—whether that be faster, slower, or at the same rate as their peers (Daradoumis et al, 2013; Saadatmand and Kumpulainen, 2012). This means that a unit that currently is span over a two-week period could take the student a day to complete or could take a student a month to complete. But, with the restriction of the 16-week semester, there are still heavy requirements and restrictions for moving through the lessons with the same amount of material that is covered in a normal lecture-based course. There would still need to be requirements on how often and how fast students would need to complete and be assessed for the various competencies in a course to stay on track for completion by the end of the semester. With this consideration, the issue of course pace might not be fixed through this implementation of eAsel because these students would still need to learn the same amount of material in the same amount of time, but now they must do a better job of self-pacing their own learning to ensure that they understand the course material as much as possible before they are ready to be assessed.

While many students felt that the course was paced too quickly, others felt as if the course was too slow. Many of the latter had already had previous programming experiences from high school, previous college classes, or family members who worked in the field. Of these students, some expressed interested in the application because they could easily skip through some of the sections that they already knew so as not to waste time listening to lectures and completing assessments that they already had a grasp for and did not challenge them.

This brings up a question as to whether students should be able to complete this course material in advance. If students who understand and have achieved mastery of the course material are able to finish

the course with several weeks or even months to spare, would these students be able to complete the semester early? Or would they have to complete extra work that went beyond or more in depth of the material taught in the course?

Assessment of Student Competency for Course Concepts

The ability to receive feedback on the level of knowledge that the student has acquired for each course concepts benefits both the professor and student. As students discussed in the interviews, they do not always receive feedback, or an adequate amount of feedback, to truly understand what concepts they need to work on in the course. eAsel's record system can be one way that can help to combat this issue.

Along with the benefits of having this information, there are also some challenges that have to be discussed to make the implementation of eAsel more seamless. These challenges are in part due to the nature of a classroom environment. These benefits and restrictions are outlined below.

Benefits of Entering Recording Student Data

By allowing students to have feedback on each individual concepts of the course, this can help students understand specifically what areas they do not understand. For instructors, they are able to understand how the students are doing with specific concepts in the course as well as receive their own level of feedback on where they need to provide more information, spend more time, or re-teach some areas that students are consistently struggling to understand. This information also would make it easier to have data analytics on how students are scoring, how many times they are scored on a specific competency, what activities they are using to learn, and how quickly they can move through the different modules.

Because the application is available through a user's phone, the ease of adding and finding information that is helpful to students when faculty members are moving around the classroom helping and interacting with students. By being able to enter data after interactions, it ensures that the interaction is relevant and easy to document, rather than having to takes notes or remember the number of interactions that the staff member had with various students.

By having a way to score and assess a student's understanding of course concepts, the student has the ability to gain instant feedback, which they are less likely to receive in a standard lecture-style classroom. As students are scored, they can know what items they still need to review to either improve their score, move onto the next module, or practice for an impending exam.

This helps the instructors reduce the amount of grading that they have to accomplish outside of the course. Because the scoring is accomplished with the student present, the professors will have more time to focus on other necessities for the classroom other than grading outside of the normal class period. As one professor said, much of their time outside of the classroom is taken up by endless grading, with the implementation of scoring the different competencies, the professors will be able to focus on specific issues that arise for the class, different lessons and resources that will help the students learn and more about the class structure itself.

Restrictions on Time during a Class Session or During Office Hours

The amount of time is very limited within the classroom. At a maximum, there are three hours where the class meets during a week. In this time, there are other aspects to the classroom that cut into this time such as formalized assessments; classroom introductions, announcements, and session conclusions; and formal lecture periods; and more that restrict the time within a normal class session during the week. In addition, other factors including how many students are registered for the course and the amount of activities that are being accomplished that day in class also impact the class time.

Giving Each Student an Appropriate Amount of One-on-One Time

The classroom is not only restricted by classroom time, but also the number of students that are registered for the course. Within the College of IST, many of the classrooms can hold approximately 50, 75, or over 100 students. This number of students can make it difficult when trying to interact and build a connection with each individual student. This experience was paralleled during both the student and instructor interviews where some students discussed the difficulty of getting enough one-on-one attention within the classroom.

This was also found while attending courses during the student learning observations and adding activity record scores into eAsel based on student interactions. During many of these course sessions, there were always multiple hands raised in the classroom. It was difficult to be able to reach all of these students in a single class period while giving each student the individual time that they needed to go over that material they were struggling with or to answer their questions. With larger class sizes it is harder to give each student the time that they deserve without feeling like less time should be spent on each of these students so that more students can be helped. In addition, with the restricted class time, it may be difficult to assess all students in a timely manner so that they can continue to progress through the course or review material when they continue to struggle.

Difficulty for Students to Score a Five

Although the five-point scale is a clear way to determine that students understand the various course concepts, there could also be difficulty in obtaining the top score of a five. One reason for this is that faculty members might not be able to spend enough time with students to determine if they were able to help other students learn the course material. During a class period, the faculty and staff members are usually helping various students and moving between groups. Because of the many activities in the classroom, an instructor or class assistant may not always notice when a student is able to help his or her

peers. In addition, it may also be difficult to fully ensure that the student provides accurate information to their peers.

The question that arises is what is considered teaching another student? Is it this student showing another how to complete a step in a program? Or, is this student required to explain a certain amount of background knowledge along with the interaction? These are questions that may have varying answers depending on the course and competency being demonstrated.

Entering Data in Real-Time

Although discussed earlier as a positive, there are also some drawbacks to entering data in real-time. Because in certain instances, a classroom can be hectic and many students may be asking for help, clarification, or assessment of a certain activity or competency, and the faculty member may have a difficult time entering all of the data required for a student score before having to move onto the next student. This could cause a lack of detail being entered as feedback or faulty data due to forgetting or mixing up different student interactions. With missing entry data into the feedback, students might have a harder time reviewing and understanding the portions of the competencies that need to be reviewed.

Assessing Students on Specific Competencies and Modular Units

Similar to working with the course structure and learning activities, assessments can also have complexities that may create challenges when assessing students on their understanding of different competencies within the course. This difficulty arose when assessing student learning through classroom and tutoring observations. Some of the assignments that students were assessed on had several working parts that had to be completed to understand the assignment or theory behind a concept. Because of this, it was at times hard to assign students a grade based on their overall understanding of the material because

they did not understand one of the several portions of the whole process. For instance, when students were creating HashMaps to determine if a search term is located in the dataset, the students may have understood how to create a HashMap, but they did not understand how to fit the item into the context of the problem, for instance, how to use a for-loop to populate the various HashMaps that had to be created from different columns in a table. Although the student understood how to create an individual HashMap and enter specific lines of keys and attributes, they did not understand how this fit into the larger context of the problem. Specifically, how loops, the pre-created data set, and a class method all worked together. Currently as the activity records page shows, there is only a single option for a score and feedback on the assessment. However, this may not always be efficient enough for the level of sophistication that the assessment requires. A few potential fixes to the problem are available.

The first is to break down the assessments into smaller modular sections that only test an individual concept in the course. For instance, in the case above, students would merely have to create a HashMap and assign it a set of keys and attributes without implementing other pieces of logic like looping.

Another option is to create a more detailed assessment page that allows the students to be scored on the individual parts of the code that are required. For instance, there will be an assessment of the HashMap, an assessment of the for-loop, and assessment of the method being created. Each of these pieces would also have the option for feedback to be assigned to the score that was provided.

Improving Student Scores after Assessment

There should be considerations with how students are instructed to improve on course material after they are given a lower score. For instance, if a student scored a 2 out of 5 because they had a lack of understanding of how to implement a nested for-loop, should the student referred back to the same material that they used previously and then re-quizzed on the same question? Or instead, is it better to

refer the student to new material that specifically outlines the areas that they did not understand and then be re-tested with a different assessment. As one professor said, if students are able to re-take an assessment, they will first jump to the assessment to see what they need to understand and then figure out what information they needed to learn to pass before re-taking the same test. If students follow this process, the students will opt for completion over deep learning of material. Considerations on how to ensure that students are learning the material affectively before assessing themselves would make the process simpler for professors and teaching assistants who would have to interact and score these students every time they want to be assessed. Assessments can become cumbersome if all students are taking and re-taking these assessments to improve their score if they did not have a handle on the information in the past.

One possible way to mitigate this is by having a pre-assessment that the students can complete to make sure that they understand all of the elements that will have to be understood before completing the assessment. By doing this, the instructors will be able to better ensure that the students have taken more time to look at the items that are required of them before the assessment. This will decrease the amount of times that the instructors or classroom assistants will have to assess these students in the different competencies.

Another way to mitigate this is by assigning a grade with each of the assessments. As the number of assessments for an individual competency increases, the score of the student can only improve by a certain percentage. For instance, on the first try they can receive all of the points associated with the competency's assessment, the second time their improved score can receive a maximum of ninety-five percent of the points, and so on decreasing the available points as the number of assessments for the same competencies are entered. By having this grading scale, students will be motivated to learn the material the first time they are taking the assessment and there will be less of a willingness to take the assessment or an equivalent assessment to improve this score.

One foreseeable problem, however, is that eventually the amount of points received will not be worth the re-assessment, and the student will then be motivated to continue their assessment of a competency that is no longer helpful towards their grade point average for the class.

Chapter 9

Conclusion

This research is helping to pave the way to implement a more personalized learning experience for students within programming courses in the College of IST. Because it is difficult to account for every learning type and sub-set of type within a single course, a more personalized experience can be one alternative to help make sure that all students are able to achieve and succeed regardless of how they learn.

Based on the data that was collected in this study, there is very little personalization within programming courses currently being taught within the college due to several restrictions based on time and the amount of information that has to be taught and learned. Even though this is the case, there seems to be interest in the implementation of a system that creates a more flexible environment for these students to learn at their own speed and use different course materials that best suit their own learning style.

Limitations

Limitations from this study stemmed from the timeline and research study, which restricted the data that could be collected and the number of features that could be tested within eAsel. Instead of completing an entire pilot study like originally planned, this research instead focused on small portions of the application, including data analytics of the entered student records as well as a walkthrough of the current application with students and instructors.

Another limitation is the number of professors that were interviewed in this research. Although a total of 5 professors were able to complete the interviews, by collecting more data from professors who teach these courses, there may have been more insights on the programming classes within the college and how eAsel could be used as a tool to help these students learn within the classroom while the professors too gained insights on this process.

Future Work

Based on the findings from this study, there is still work that must be done with eAsel. One of these tasks is to determine which courses would benefit from the use of the eAsel application. Not all courses are suited to have this re-design based on the framework outlined in eAsel. Research will have to be done to determine which classes can work with this implementation. Once this is determined, steps should be taken to complete a pilot study that implements a fully functional eAsel course. By conducting this pilot study, the instructors and researchers involved will have a greater understanding of how to design the course to help its students while also effectively structuring each of the important competencies covered in it.

Future research should also focus on the experience of an instructor within the classroom. Although the application focused on helping students better learn course material through a newly implemented class framework, there can still be work on the instructor's experiences within the classroom. Specifically, this research can focus on the time, tasks, and other aspects of the course, which creates challenges to the course and its structure during a semester.

Appendix A

Student Interview and Guided Walkthrough Guide

Consent Form

1. Give the participant two consent forms, and let them read over the document and sign/date
2. Explain to the participant that they are able to withdraw from the study at any time

Introduction

Thank you for participating in this interview. The goal is to better understand student experiences within programming courses in the College of IST, understand how students learn, and how courses can be adapted in future semesters to better help students understand course concepts. This interview should take no longer than an hour.

This interview is broken down into two sections. The first is interview questions to better understand students. For instance, there will be questions about your academic background, what courses you have taken, how these courses are structured, and different processes you have used to learn course concepts.

The second part of the study I will be walking you through an application called eAsel that is used to foster personalized learning within a course. I will run through a scenario of how this application can be used within the course. During this time, you will be able to talk about your impressions of the application as I walk through and explain how to use the application.

During this study, I will be both taking notes and recording your answers. Is it okay if I record your answers during this study?

Interview Questions

1. What is your major(s)/option(s) and/or minor(s) within the college? Circle all that apply.

   Majors:

   IST: ISDEV ITINT ISPP

   SRA: IAM ICS

   DS: Applied Computational Statistical Modeling

   Cyber: Geopolitics Law & Policy Economics Health Care Custom

   Other: _____

   Minors: IST SRA ENTI Other: _____

2. What is your class standing? Circle the one that applies.

   Freshman Sophomore Junior Senior Senior+

3. What programming courses have you taken in the College of IST? Circle all that apply.

   IST 140 IST 210 IST 240 IST 242 IST 261 IST 311 IST 361 IST 411 IST 412 IST 413 Other: _____

4. Thinking about how you learn inside and outside of the classroom, what methods of learning have you employed to better understand course concepts?

5. Are these methods used within your classroom setting? And how is a normal class period structured?

6. Outside of the individual concepts, what challenges (if any) do you encounter in your programming course(s) when learning course concepts?

7. Have you ever sought outside resources to aid learning? If so, what?

8. Has a course ever progressed at a pace that was either too slow or too fast? How did you mitigate this?

9. When moving on to new units in the course, or next levels of a course, has the knowledge of past lessons been able to be retained?
10. How could these programming courses adapt to better help your learning process?

Guided Walkthrough

Introduction

For this section of the study, I will be demonstrating the eAsel application, this walkthrough will demonstrate a student learning about conditional statements (or if statements) in Java. Throughout this demonstration voice your opinions and speak out loud to your reactions of the application.

Description

For this study, we will be walking through an application called eAsel, which is used to help handle courses that follow a competency-based learning framework while still allowing students the flexibility to personalize their experience.

During this walkthrough we will be demonstrating how a course is created, how students can interact with the site, and how professors can use the application to assess student knowledge of different course concepts.

Throughout this demonstration voice your opinions and speak out loud to your reactions of the application.

Introduction to the Personalization & Competency-Based Approach Framework

1. Show and describe document with flow chart (seen in Figure 6).
    a. Before starting, courses in eAsel follow a three-level framework. These levels are objectives, competencies, and activities. In this framework, overarching course goals are placed in objectives, which are broken down into sub-goals called competencies. For each competency, students can complete as many or as little activities as they need before they are ready to be assessed. When a student is assessed and certified in a competency, he/she is able to move onto the next competency and objective and so on.
    b. Students are assessed based on a 5-point scale, based on their level of understand at the time of assessment.

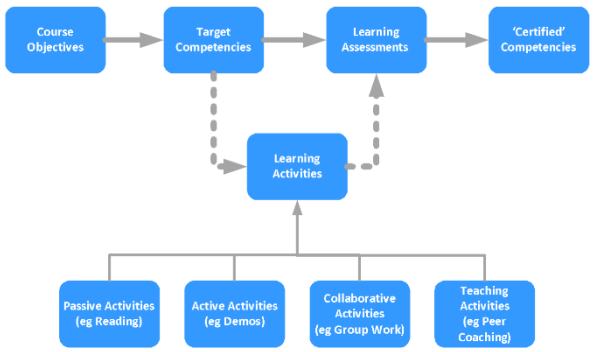
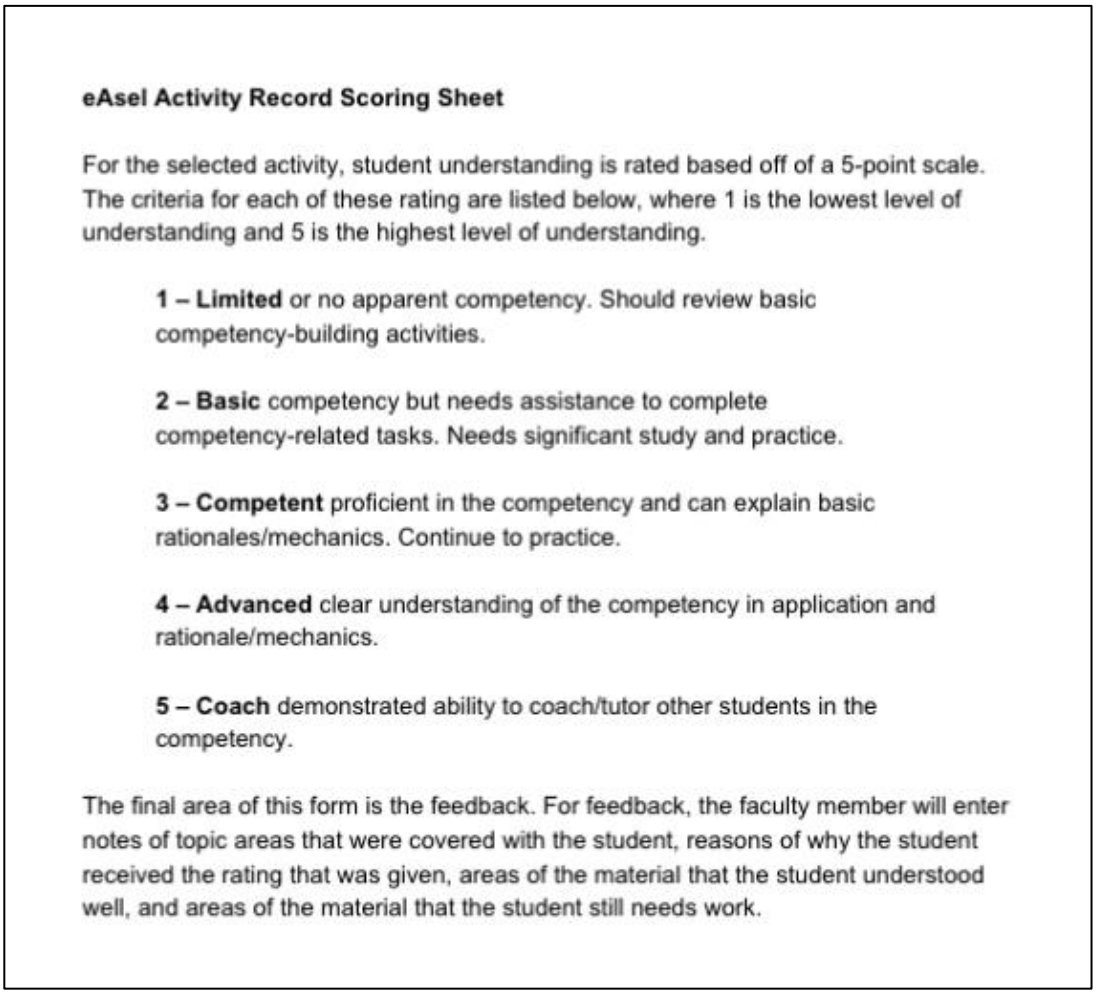


Figure 6. Personalized Learning Approach for Programming and Application Development Courses (Haynes, 2017).

2. Show record scoring document, and explain records scoring document (seen in Figure 7).
    a. When students are assessed, this helps both the students and instructors know their level of understanding, what knowledge has been digested and what (if any) knowledge still must be attained.
    b. This application is meant to be used in parallel with current classroom systems, like Canvas. It is not a replacement for anything.



eAsel Activity Record Scoring Sheet

For the selected activity, student understanding is rated based off of a 5-point scale. The criteria for each of these rating are listed below, where 1 is the lowest level of understanding and 5 is the highest level of understanding.

1 – Limited or no apparent competency. Should review basic competency-building activities.

2 – Basic competency but needs assistance to complete competency-related tasks. Needs significant study and practice.

3 – Competent proficient in the competency and can explain basic rationales/mechanics. Continue to practice.

4 – Advanced clear understanding of the competency in application and rationale/mechanics.

5 – Coach demonstrated ability to coach/tutor other students in the competency.

The final area of this form is the feedback. For feedback, the faculty member will enter notes of topic areas that were covered with the student, reasons of why the student received the rating that was given, areas of the material that the student understood well, and areas of the material that the student still needs work.

Figure 7. Student Activity Record Scoring Guide

The Guided Walkthrough

Navigating to eAsel

3. Navigate to eAsel and sign-up as a user.
    a. When we navigate to eAsel we are able to login and sign-up. When a new user is created, there are three different user types that can be created: a course master (who creates a

course), an instructor (who owns specific instances/sections of a course), and a student (who is a member of a course).

   b. Throughout this walkthrough we will take part as two of these types of users: students and professors. To start, we will log in as a student.

4. Log-in to eAsel.
   a. Once logged in, you can see the dashboard which lists the courses that the user is a student of, and it shows one of the courses in the body of the page with all of the data that is associated with it.
   b. There is a section, which is associated with the section the student is in within the course.
   c. In this course you can see all of the resources associated with the course broken down into the objectives, competencies, and activities framework discussed earlier.
   d. For instance, one of the objectives is Understanding Programming Basics, a competency is Understanding a Computer's Anatomy, and activities is a reading called Big Java, Late Objects pg 3.
   e. For activities, there are several options of how this activity can be categorized.
5. Describe each of the types listed in outline dropdowns.
   a. An activity can also be active and collaborative. Where the learning is being put in their hands or group collaboration is taking place.

Viewing an Activity

6. Log-in and click on activities in the dashboard.
   a. Now that the course has activities, a professor and students can log in and look at course material.
7. Navigate to the Horstmann textbook.

a. Once a student feels they understand the material, they can be assessed for that understanding based on the 5-scale discussed earlier.

Enter Student Records

8. Log in as a professor.
9. Navigate to the add records page.
    a. When adding a record, the professor can choose the student and specific activity in which the student can be assessed. In this case it is an ATM activity. Data and feedback can be entered to give a better understanding of what the student knows and what they are still struggling with.
10. Navigate to analytics page.
    a. Once records are created, you can see this record and filter them based on the specific criteria that is being viewed.

Resulting Questions

1. What were your reactions towards the eAsel application?
2. Could this type of application effect student's ability to learn within the classroom?
3. Would you use this application in your courses if it were accessible? Why or Why not?

Appendix B

Instructor Interview and Guided Walkthrough Guide

Consent Form

1. Give the participant two consent forms, and let them read over the document and sign/date
2. Explain to the participant that they are able to withdraw from the study at any time

Introduction

Thank you for participating in this interview. The goal is to better understand student experiences within programming courses in the College of IST, understand how students learn, and how courses can be adapted in future semesters to better help students understand course concepts. This interview should take no longer than an hour.

This interview is broken down into two sections. The first is interview questions to better understand students. For instance, there will be questions about the courses you teach, how these courses, how they are structured, and student challenges.

The second part of the study I will be walking you through an application called eAsel that is used to foster personalized learning within a course. I will run through a scenario of how this application can be used within the course. During this time, you will be able to talk about your impressions of the application as I walk through and explain how to use the application.

During this study, I will be both taking notes and recording your answers. Is it okay if I record your answers during this study?

Interview Questions

1. What is your title?
2. How long have you taught in the College of IST?
3. What courses have you taught in the College of IST? Circle all that apply.

   IST 140 IST 210 IST 240 IST 242 IST 261 IST 311 IST 361 IST 411

   IST 412 IST 413 Other: _____
4. What pedagogy do you use in your course(s)? (E.g. problem-based learning, lecture, etc.)
5. In your course, how (if any) is learning personalized to fit different student needs in your course(s)?
6. What methods have been used to help personalize learning in courses you have taught?
7. How do you assess student competencies with different didactics? (E.g. procedural, informative, etc.)
8. Do you focus on attainment of specific competencies, and how do you measure these competencies?
9. What challenges do you find in your course(s) that inhibit student learning?

Guided Walkthrough

Introduction

For this section of the study, I will be demonstrating the eAsel application. This walkthrough will demonstrate a student learning about conditional statements (or if statements) in Java. Throughout this demonstration voice your opinions and speak out loud to your reactions of the application.

Description

For this study, we will be walking through an application called eAsel, which is used to help handle courses that follow a competency-based learning framework while still allowing students the flexibility to personalize their experience.

During this walkthrough we will be demonstrating how a course is created, how students can interact with the site, and how professors can use the application to assess student knowledge of different course concepts.

Throughout this demonstration voice your opinions and speak out loud to your reactions of the application.

Introduction to the Personalization & Competency-Based Approach Framework

1. Show and describe document with flow chart (seen in Figure 8).
    a. Before starting, courses in eAsel follow a three-level framework. These levels are objectives, competencies, and activities. In this framework, overarching course goals are placed in objectives, which are broken down into sub-goals called competencies. For each competency, students can complete as many or as little activities as they need before they are ready to be assessed. When a student is assessed and certified in a competency, he/she is able to move onto the next competency and objective and so on.
    b. Students are assessed based on a 5-point scale, based on their level of understand at the time of assessment.

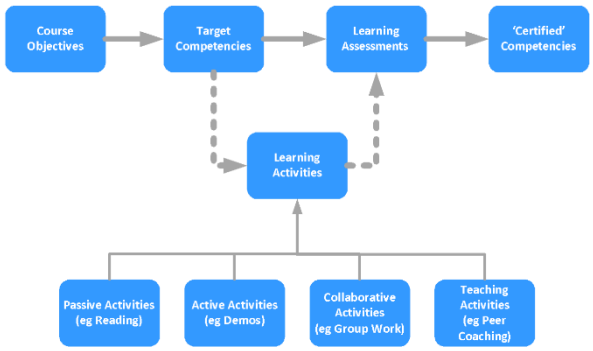
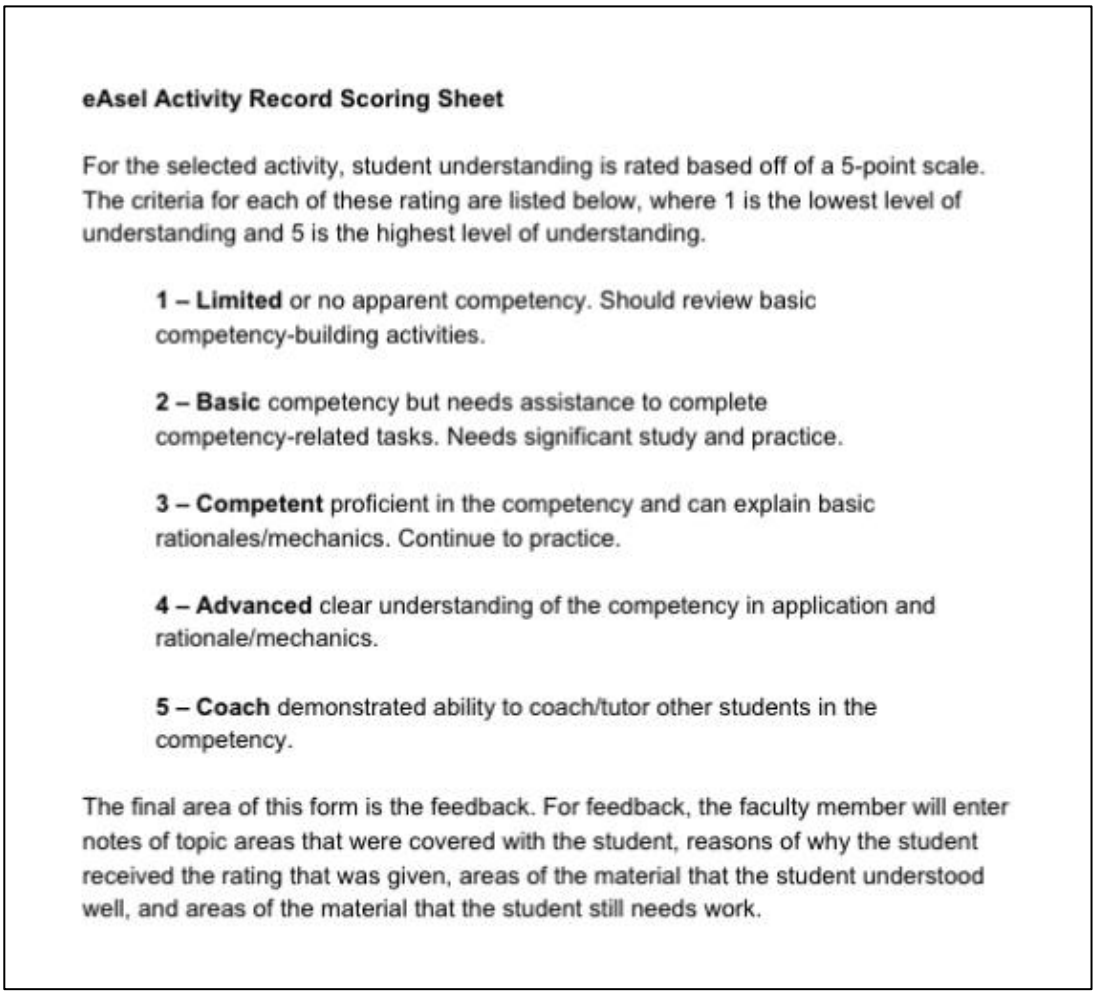


Figure 8. Personalized Learning Approach for Programming and Application Development Courses (Haynes, 2017).

2. Show record scoring document, and explain records scoring document (seen in Figure 9).
    a. When students are assessed, this helps both the students and instructors know their level of understanding, what knowledge has been digested and what (if any) knowledge still must be attained.
    b. This application is meant to be used in parallel with current classroom systems, like Canvas. It is not a replacement for anything.



eAsel Activity Record Scoring Sheet

For the selected activity, student understanding is rated based off of a 5-point scale. The criteria for each of these rating are listed below, where 1 is the lowest level of understanding and 5 is the highest level of understanding.

1 – Limited or no apparent competency. Should review basic competency-building activities.

2 – Basic competency but needs assistance to complete competency-related tasks. Needs significant study and practice.

3 – Competent proficient in the competency and can explain basic rationales/mechanics. Continue to practice.

4 – Advanced clear understanding of the competency in application and rationale/mechanics.

5 – Coach demonstrated ability to coach/tutor other students in the competency.

The final area of this form is the feedback. For feedback, the faculty member will enter notes of topic areas that were covered with the student, reasons of why the student received the rating that was given, areas of the material that the student understood well, and areas of the material that the student still needs work.

Figure 9. Student Activity Record Scoring Guide

The Guided Walkthrough

Navigating to eAsel

1. Navigate to eAsel and sign-up as a user.
    a. When we navigate to eAsel we are able to login and sign-up. When a new user is created, there are three different user types that can be created: a course master

(who creates a course), an instructor (who owns specific instances/sections of a course), and a student (who is a member of a course).

   b. Throughout this walkthrough we will take part as each one of these types of users. To start, we will log in as a course master.

2. Log-in to eAsel.
   a. Once logged in, you can see the dashboard which lists the courses that the user is a member or owner of, and it shows one of the courses in the body of the page with all of the data that is associated with it.

Creating a Course in eAsel

3. Create a course.
   a. When a course is created, it becomes visible on the dashboard and is listed on the left-hand panel with the other courses.

Creating an Objective in a Course

4. Click add an objective.
   a. As discussed earlier, courses are built from objectives. For instance, creating a course for understanding the actual hardware of the computer before beginning to program.
   b. We can add as many objectives as needed for the course. These objectives will begin to show up in the body of the page.

Creating a Course Competency

5. Create a competency within the first objective.
    a. Once created, this will show up within the objective block. Just like objectives, several competencies can be created within the same scope.

Create Activities

6. Navigate to the activities page.
    a. When creating an activity, there are several options of how this activity can be categorized. Describe each of the types listed in outline dropdowns.
    b. An activity can also be active and collaborative. Where the learning is being put in their hands or group collaboration is taking place.

Create a New Section

7. Add a section.
    a. Once a course is created, copies of this course can be created by entering information about the section of the course. In this functionality, once a class has a section, it can add and remove items without affecting the original course set up.
8. Add a professor.
    a. Once the section is created, professors and students can be added to the course.
9. Sign-out and log-in as a professor.
    a. Once the course has been shared, a professor can see the class within their home dashboard.

Adding students to the Course

10. Navigate to the roster.
    a. When a section is created, students can be added to the course so that they can access the course material.

Student View

11. Log-in and click on activities in the dashboard.
    a. Now that the course has activities, a professor, and students, a student can log in and look at course material.
12. Navigate to the Horstmann textbook.
    a. Once a student feels they understand the material, they can be assessed for that understanding based on the 5-scale discussed earlier.

Enter Student Records

1. Go back to the professor login.
2. Navigate to the add records page.
    a. When adding a record, the professor can choose the student and specific activity in which the student can be assessed. In this case it is an ATM activity. Data and feedback can be entered to give a better understanding of what the student knows and what they are still.

Resulting Questions

1. What were your reactions towards the eAsel application?
2. Could this type of application be beneficial within the classroom?
3. What features do you feel are important to have for this application?
4. Would you use this application in your courses if it were accessible?

Appendix C

eAsel Data Collection: Student Scoring Sheet

When working with students, both in IST 242 and during tutoring sessions, students' understanding of course competencies are rated based on a five-point scale. This rating data will be entered within the eAsel application (easel.scenomi.com). To do this, the researcher will follow the steps outlined below.

Navigating to the Rating Criteria

1. After logging into the site, but researcher will click the course that the student received help in (i.e. IST 140, IST 240, or IST 242).
2. The researcher will select the section of the course (for this study there will only be one section of each of the courses listed above).
3. The researcher will select "Add Activity Record" which will navigate to the rating page.

Entering the Rating Data

Figure 10 is a screenshot of a sample student rating page in which the researcher will use to enter the level of student understanding for various course competencies within the IST 140, IST 240, and IST 242.

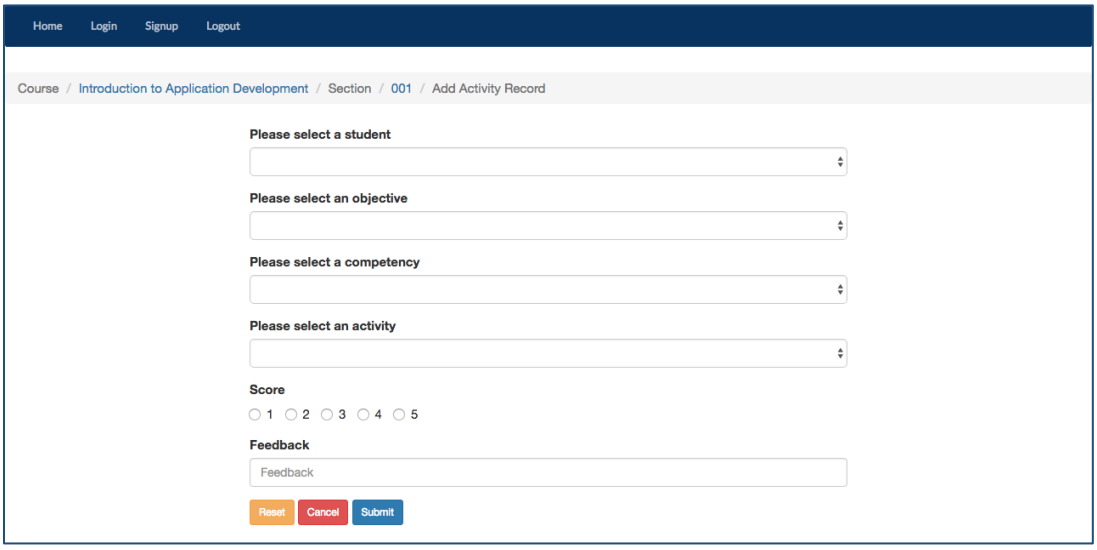


Figure 10. Activity Record Page in eAsel.

For the student, each record that is entered will be named based on the course and the number of students that have already been rated for this course. For instance, if the researcher is working a student in IST 140, this student will be recorded as 140-1, the next student will be recorded as 140-2 and the ending value will continue to increment throughout the study. By doing this, the actual students being recorded will be kept anonymous within the eAsel system because their name and information are not tied to these ratings.

The researcher will also select the course objective, competency, and activity that the student receiving assistance will be rated on. These categories are specific to the course in which the student is taking. For instance, a student could be learning about conditional statements. In this case the objective could be “conditional statements”, the competency could be “nested if-statements”, and the activity could be “Chapter 3 programming practice - nested conditional statements.”

For the selected activity, student understanding is rated based off of a 5-point scale. The criteria for each of these rating is listed below, where 1 is the lowest level of understanding and 5 is the highest level of understanding.

1 – Limited or no apparent competency. Should review basic competency-building activities.

2 – Basic competency but needs assistance to complete competency-related tasks. Needs significant study and practice.

3 – Competent proficient in the competency and can explain basic rationales/mechanics. Continue to practice.

4 – Advanced clear understanding of the competency in application and rationale/mechanics.

5 – Coach demonstrated ability to coach/tutor other students in the competency.

The final area of this form is the feedback. For feedback, the researcher will enter notes of topic areas that were covered with the student, reasons of why the student received the rating that was given, areas of the material that the student understood well, areas of the material that the student still needs work, and comments of how the feedback form can be updated to better capture student understanding.

After all of the data is entered, the researcher will click the “Submit” button so that it is recorded within the database.

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ACADEMIC VITA

EDUCATION

The Pennsylvania State University, University Park, PA
Integrated Undergraduate Graduate (IUG) Program | Schreyer Honors College
Master of Science in Information Sciences and Technology (IST)
Bachelor of Science in Information Sciences and Technology
Bachelor of Science in Security and Risk Analysis (SRA)

SKILLS

PROGRAMMING LANGUAGES: C, CSS, C++, C#, HTML, Java, JavaScript, JQuery, MATLAB, .NET, PHP, Python, SPL, SQL, XML
SOFTWARE: ACH, Adobe Dreamweaver CC, Adobe Photoshop CS5, Analyst Notebook, Android Studio, Atom, Axure, Balsamiq Mockups 3, Brackets, CA Agile (formerly known as Rally), Drupal, Eclipse, GitHub, GoogleTest, GoogleMock, InteliJ IDEA, Jira, MATLAB, MS SQL Server 2008, MS Office, MS Visual Studios, NetBeans, Pivotal Tracker, RUI, SharePoint 365, Splunk, Sublime Text 2, Tableau, Terminal, Windows CMD, WordPress

WORK EXPERIENCE

Research and Development Engineer **December 2018 – Present**
The Pennsylvania State University Applied Research Laboratory (ARL), State College, PA
- Writes code in C and C++ to meet project requirements defined by the client
- Meets with engineers and mathematicians to ensure code quality for desired results
- Develops data visualization tool in MATLAB to help engineers analyze product data for quality and validity

Mission Systems Cybersecurity Intern **May 2018 – August 2018**
Northrop Grumman Corporation, Annapolis Junction, MD
- Used machine learning algorithms to better determine network intrusions and refine signatures, which concluded with presenting findings to the client
- Worked with CSOC (company network traffic) data in Splunk's Machine Learning Toolkit to determine true positive confidences of detected intrusions
- Designed wireframe mockups with Balsamiq Mockups 3 to demonstrate future implementation into the client's network
- Served as team product owner to assign and manage the tasks of 12 team members in CA Agile (formerly known as Rally)

Information Technology & Data Analytics Summer Intern **May 2017 – August 2017**
The Boeing Company, Hazelwood, MO
- Implemented the GoogleTest and GoogleMock unit testing frameworks into the Integrated Product Data Management (IPDM) team's environment
- Created mock classes and unit tests against Teamcenter code in C and C++, and trained 30 team members on creating unit tests and mock classes
- Designed and presented a Cybersecurity awareness project to cybersecurity professionals about implementing safe and secure practices company wide

IT Summer Intern for Software Security Assurance (SQA) Team **June 2016 – August 2016**
Johnson & Johnson Services, Inc., Raritan, NJ
- Monitored user logs for agile tools by parsing entries and creating dashboards with Splunk
- Created a Tableau dashboard to analyze SQA team reviews and observations data for projects throughout the company from an Excel spreadsheet
- Migrated over 5,000 documents, lists, calendars, and permissions of SQA data to SharePoint 365 for the SQA team site and SEM Portal site

Systems Analyst/Developer Intern **May 2015 – August 2015**
Berks County Intermediate Unit, Reading, PA
- Streamlined and enhanced an inner company ticket system by using .NET programming and SQL to keep all activity within the application
- Worked with the software development life cycle, systems analysis, application/database design, software/database development, and testing

Co-Coordinator of the IST Peer Tutoring Program **January 2015 – December 2018**
The Pennsylvania State University, University Park, PA
- Ran tutoring sessions where students could get help with their Java, SQL, web design, and network classes
- Managed 4 tutors and 8 Learning Assistants, and worked with 5 faculty members
- Hired new tutors by reviewing applications and interviewing candidates

Resident Assistant (RA) for the Engineering House Special Living Option **August 2015 – May 2018**
The Pennsylvania State University, University Park, PA
- Designed an Android app using Java, XML, and JSON to create a ticket system for residents to report issues and communicate with their RA
- Managed and assisted 85 students with emotional, academic, and social needs, as well as planned building events to build a living community
- Worked with fellow Resident Assistants, Building Coordinators, and House Executive Board members to enforce campus and residence hall policies

Instructional Assistant **August 2014 – May 2018**
The Pennsylvania State University, University Park, PA
- Supported 4 courses in the College of IST under 4 professors by preparing assignments, answering emails, and giving lectures in professor's absence
- Graded assignments and supported a class of as many as 75 students during class and office hours

LEADERSHIP AND VOLUNTEERING EXPERIENCE

- National Residence Hall Honorary — November 2018 – May 2019
- THON Volunteer, Special Projects Team Project Manager for Technology Captain Committee — April 2017 – April 2018
- THON Volunteer, Rules and Regulations Committee — September 2013 – February 2017
- Pro Expo (College of IST Fall Career Fair) Student Committee Co-Lead — April 2017 – September 2017

CERTIFICATIONS AND HONORS

College of IST Letter of Recognition for the National Center of Academic Excellence in Information Assurance and Cyber-Defense by the National Security Agency (NSA) and Department of Homeland Security (DHS)
Microsoft Office Specialist (MOS) in Microsoft Excel, Microsoft Word, and Microsoft Power Point
Dean's List 11 of 11 semesters
College of IST Student Marshal Summer 2019