Worcester Polytechnic Institute

RBE 3001: Virtual Study Aid Final Project Report

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Abstract

The undergraduate robotics courses at Worcester Polytechnic Institute (WPI) present a unique challenge in that they are the first of their kind. There is therefore no appropriate textbook that specifically addresses the material taught in the Unified Robotics I: Actuation (RBE 2001) class at WPI. When the idea to develop a virtual study aid for this class arose, the question that was asked was: “In the development and implementation of a virtual study aid, specific to the content of RBE 2001; --what would be the most effective method of presenting the material?” This study will seek to answer this question, and complete the steps to creating a virtual study aid.

Executive Summary

Due to its infancy, the Robotics Program at WPI lacks textbooks covering material specific to the undergraduate courses. This can be a hurdle for many students; extra time is needed to find accurate sources of information outside of course materials. With this in mind, the group hopes to generate a virtual study aid covering some of the topics presented in RBE 2001 to lessen the loss of time and improve student understanding of the course material.

A pilot of this virtual study aid was developed by first researching the topics of virtual learning, human computer interaction, and learning styles. Furthermore, existing virtual study aids and online courses were analyzed to provide a basis for developing an electronic learning tool. This assisted in presenting the course material. Analysis was also done on which platform to use in the development of the virtual study aid. When evaluating and choosing the platform, which features and devices to support were considered.

The pilot virtual study aid was created using Adobe Dreamweaver to create HTML documents. Videos, inline questions, and figures were also incorporated. The videos were created using Camtasia. The figures were created using Microsoft Visio.

Student performance on course material was used prioritize the order of chapter development. Once deployed, additional data was gathered through a focus group; this

data helped to determine the effectiveness of the pilot. The focus group was asked questions to help evaluate the study aid pilot and suggest improvements.

With the data collected, analysis of the virtual study aid was able to be completed. This provided feedback on how effective the virtual study aid is, as well as provided a foundation for further improvement. Future projects can use this information to make the virtual study aid a comprehensive tool for the entire course.

Introduction

Part I: Problem Description

Although there are many resources covering the topics from RBE 2001, there is not an appropriate comprehensive resource encompassing all topics in the class. Currently, while students in the RBE 2001 course work on their homework or lab assignments they must look through various sources cited by the professor or seek additional information online. This leads to multiple problems for the students.

- The information online may take a long time to locate, taking away from the time that the students have to learn the subject matter and complete assignments.
- The student may not locate the extra information they need or it is not in a format that is helpful to them.
- The information that students find may be incorrect.

Part II: Why Is It Important?

The creation of a virtual study aid for the RBE 2001 class is important for several reasons. The first reason is that a secondary source, which covers all material presented in lecture, is a helpful method of reinforcement and will save time on the part of the student.

Having a secondary reference specific to the class is important. The pilot virtual study aid was created so that it contains no superfluous information that does not pertain to the subject of the class. This allows students to receive the information they need

without having to search through unrelated subjects. It also ensures that information is readily available so that students do not have to spend study time trying to find information from multiple sources.

The fact that the tool is electronic makes some important features available. The electronic learning tool has the advantage of being easy to update and maintain. This will allow the professor to change information over time or to even add or remove sections as they gain or lose pertinence to the course. Interactivity is almost impossible to achieve in a printed resource but comes naturally in an electronic one. For example, students may view practice problems at the end of a reading assignment. They will solve the problem and enter their answer. The students will then be told if their solution is correct or not. This will allow students to receive feedback immediately. It is also possible to display the steps required to solve a problem, helping students learn.

It is also important to remember that the virtual study aid has the purpose of helping the students. This means that the aid must be effective for the user. This led the team to research electronic learning. Electronic Learning is considered to be all learning involving electronic media such as, (but not limited to) eBooks, computer programs, interactive websites, online courses, and electronic homework software.

Part III: Brief Background

Before developing a virtual study aid it was necessary to do some background research. In doing so it was necessary to look at different learning styles and current online learning applications. Researching different learning styles as well as current

applications helped in the decision of how to best present information for maximum effect. It was also necessary to closely examine effective user interface design. Students may prefer not to use a site that is difficult to use, and instructors may not update the material very often if the process for doing so is difficult. Usability is therefore very important in applications such as this.

Part IV: The Project

The Unified Robotics 1 class currently has a heavy reliance on extra-curricular materials in lieu of a textbook. For this reason the Robotics Engineering 2001 Interactive Qualifying Project (RBE 2001 IQP) team sought to introduce a virtual study aid to the RBE 2001 course. The group defines a virtual study aid as a secondary source which reinforces material through an electronic medium. Virtual study aids may vary greatly. They may be anything from online study cards to video lectures or interactive exercises. The RBE 2001 class currently runs without a textbook and it was the team's goal to create an effective virtual study aid in the hope of increasing student satisfaction of the course.

When considering learning through the use of an electronic tool, the topics of Human-Computer Interaction and User Experience are very important. Usability for the students that rely on the tool is one of the most important aspects of what makes an electronic learning tool successful. While studying different types of electronic learning, different learning styles such as: print, visual, aural, kinesthetic, verbal, haptic and olfactory were researched. The thought was to design a tool that improved the experience of visual, aural, print, haptic, and kinesthetic learners.

Along the way, the group has reviewed the course material of the RBE 2001 class. The purpose of this was to begin preparations for the creation of content that belongs in the virtual study aid.

Part V: The Virtual Study Aid

The final product of this project is a pilot virtual study aid for the RBE 2001 Class. The pilot virtual study aid is an HTML project developed using Adobe Dreamweaver. The template of the virtual study aid was designed by the team and can be used for every page in the study aid.

The instructional text of the virtual study aid was adapted from lectures using voice to text software. Figures were added to textual portions of the study aid. These figures were generated using Microsoft Visio. Videos were also created using Camtasia. These videos are hosted on YouTube and embedded in the study aid. The videos are in separate sections at the end of each chapter.

Background

Part I: The RBE 2001 class

The RBE 2001 class is currently taught using a mixture of PowerPoint presentations, references to published readings on robotics, and an organized lab section. Therefore, there is no singular resource that a student can reference to answer questions related to the course. While doing homework, students tend to use a mixture of class notes, teaching assistants, and their own research on the topic. This is a considerable hurdle that is unique to the robotics curriculum; most other classes have a comprehensive textbook where all information covered in the class can be found.

Figure 1: Textbooks for RBE 2001

Discipline	Textbook
Mechanical Engineering	Design of Machinery, 4th ed.
Control Engineering	Robot Modeling and Control, 2nd ed.
Multi-disciplinary	Springer Handbook of Robotics
Computer Science	Introduction to Autonomous Mobile Robots

Figure 1 presents the different textbooks that currently cover the material in the RBE 2001 class. A single virtual study aid would reduce the amount of time students spend sifting through extraneous information.

Part II: Research of Learning Styles

In order to create an effective learning aid, it was important for the group to understand different learning styles people might have. These learning styles were then taken into consideration in the presentation of RBE 2001 material. People often have multiple learning styles. Learning styles are the way in which different people process and retain information (Dunn, Griggs). There are seven different learning styles: print, aural, visual, haptic, interactive, kinesthetic, and olfactory (ILSR). In addition to this, there are two learning styles that indicate whether a student is a solitary or social learner.

Print refers to reading or seeing written text (ILSR). A print oriented learner easily learns by reading. They may learn better after seeing or writing down material. These individuals often enjoy reading and may be perceived as a bookworm (ILSR).

The aural learning style is often associated with musicality (ILSR). Aural learners may have good pitch and an excellent sense of rhythm. Recordings of a class or lecture, as well as rhythmic mnemonics may be helpful for this type of learner. These learners might find it useful to talk themselves through procedures. The aural learner is often an excellent listener and can learn well through traditional lectures (ILSR).

A visual learner learns by seeing and watching demonstrations (ILSR). These learners prefer the visual arts and media. These learners might benefit from creating charts and diagrams. They may also better understand a concept if they are able to visualize it in

their “mind’s eye”. These individuals may find it difficult to listen to instruction for an extensive period of time (ILSR).

The haptic learner enjoys a “hands on” approach to learning (ILSR). These learners may enjoy doing artwork, doodling and tracing words or pictures (ILSR). These individuals enjoy tasks that require manipulation. They can often be seen fiddling with something.

Interactive learners benefit through verbalization (ILSR). These individuals can benefit largely from question and answer sessions, as well as discussing class material with peers. They prefer to discuss things with others and are not often quiet for a long period of time (ILSR).

The kinesthetic learning style is already utilized in the lab sections of the RBE 2001 class. Kinesthetic learners enjoy making physical models of concepts. They are the type of students who would prefer to just take something apart and put it back together to discover how it works in lieu of reading a manual. They have difficulty sitting through lectures and may want to get up and move around. These learners do well when they can physically interact with the objects they are learning about (ILSR). These learners also use movement to help concentrate (ILSR).

Olfactory learners learn best through the sense of smell or taste (ILSR). For these individuals smell is very significant; they may strongly associate a specific smell with a previous memory. These learners find that smell assists in learning (ILSR).

Social learners prefer learning in groups or classes, or like to spend time one-on-one with a professor or TA. These learners have great communication skills. These are the type of people who benefit more from study groups. Working in groups is helpful as seeing where others make mistakes helps the learner to avoid the same mistakes in the future.

Solitary learners are more private, introspective and independent. Focusing on their own thoughts helps the solitary learner to concentrate. When these learners communicate with a professor or TA they only ask information they haven't been able to clarify themselves. It is important that these learners take a personal interest in what they are learning.

Figure 2: Learning Styles from RBE 2001

Print	Lecture
Interactive	Q/A with TA, Office Hours
Kinesthetic	Labs
Social	Labs, Office Hours
Solitary	Homework
Aural	Lecture

As can be seen from Figure 2, several learning styles are already featured in the RBE 2001 class. The lecture portion of this class incorporates both print and aural learning styles. Office hours and question & answer sessions as well as discussions with classmates help the interactive and social learner. The Lab portions of the class are

great for the kinesthetic and social learners. Homework can be good for solitary learners.

Learning styles which aren't as well addressed are visual and haptic learning styles. The study aid addresses the visual learner with the use of videos and diagrams. The haptic learning style will be addressed with interactive figures in future versions of the study aid. The olfactory learning style was found to not be applicable to the RBE 2001 class.

The seven different learning styles were analyzed, and then were useful in the construction of the virtual study aid for the RBE 2001 class. Since the goal is to make the virtual study aid effective, it is important that many learning styles are utilized.

Part III: Previous Studies on the Topic of Electronic Learning

In order to further explore the effectiveness of electronic learning, several other studies involving electronic learning were researched. These studies also serve as a guide for how to make this electronic aid as effective as possible.

The first of these studies created an intelligent web based tutoring system that would incorporate student's learning styles. This system was called UZWEBMAT; the purpose of this study was to evaluate the effects of this system on students' learning of 10th grade probability (Baki). This system took into account students' dominant learning style. Information was presented to each student based on what their dominant learning

style was. It was determined that UZWEBMAT was helpful to both students and teachers as it helped the students to better learn as well as provided feedback for teachers. This led the group to examine the possibility of utilizing learning styles in the virtual study aid as well as providing feedback to professors. As these features were important in a previous tool they could possibly be useful for this application. Upon further investigation, however, the team decided to focus on the fundamental elements of the virtual study aid. They decided to do this in a way which would allow for future expansion into areas such as this.

The second study that was looked at examined the effectiveness of digital game-based learning (Yang). Two metrics were recorded, learning motivation and academic achievement. The digital game based learning was clearly effective in improving students' problem solving skills. Also there was an increase in learning motivation associated with the digital game-based learning. There was, however, no statistical improvement in academic achievement between the control and study groups. This study suggests that interactivity in the virtual study aid may enhance the student experience for RBE 2001. There is however no conclusive evidence that interactivity may improve student performance.

The ASSISTments project that has been a work in progress for many years at WPI was also looked at briefly. ASSISTments is a tool teachers can use to administer homework problems online (Wu, Svirchuk and Heffernan). Although ASSISTments has been attempting to develop some tutoring capabilities using scaffolding questions, it currently exists primarily as a tool for teachers to gauge their students' progress. These

scaffolding questions are a step by step tutoring tool, that breaks problems into steps. It may be beneficial to implement such a tutoring system in the virtual study aid. This, however is not the focus of this project and therefore less relevant than other studies.

Although not directly applicable, a number of online course offerings were initially examined in the hope that they may provide additional information with respect to the effective presentation of electronic media. Many universities offer either hybrid virtual/in-person course offerings, or entirely virtual online classrooms. As a result, there exists a myriad of different platforms and formats for presenting information electronically in this fashion. Specific programs being researched are DeVry University (offering entirely online college degree programs), Stanford University's online courses (perhaps the world record holder for the largest single class size ever), Massachusetts Institute of Technology's free offering of recorded lectures, and Quinsigamond Community College's deployment of the MyMathLab system as a tool for students. [Saenz, Aaron] Information regarding the effectiveness of the presentation of information each program is still being collected, but they may yet harbor important lessons applicable to our virtual study aid.

In order to understand what some of the software packages offered, a program already in use at Quinsigamond Community College called MyMathLab was analyzed. MyMathLab has instant feedback on question answers, step by step solutions with student input at each step, a full explanation of how to solve each problem, a record of the amount time spent on each exercise, video on how to solve the problems, and a link

to an eBook section related to the problem. There are various learning styles addressed here and many features that may be useful in the RBE 2001 class.

The Uki Wiki was also examined. This wiki is geared toward the engineering and science community, initially toward the robotics engineering community at WPI (O'Meara et al.). At that time it was made, it attempted to address some of the issues that this IQP is also attempting to remedy; the lack of a single source of information for the undergraduate robotics curriculum as there are no textbooks specifically designed for the Unified Robotics courses. It falls short in that it does not cover all the material of the robotics course. It also is a wiki, so it assumes users will go onto the wiki and edit information or answer questions. The primary problem with this is that after a student has completed RBE 2001 they may have little motivation to update information. Information is not moderated so it may be incomplete or worse, incorrect. It also does not address different learning styles of students or present information in the most effective way possible.

Part IV: Human-Computer Interaction

In order to make the virtual study aid as helpful as possible to both students and professors it needs to be easy to use. In order to do this it was necessary to use accepted design principles and practices.

Whenever information is presented in an electronic format, it is important to investigate the best way to spatially present this information. This is necessary so that user

interaction with the electronic media is intuitive. It is also important so that information is properly grouped in order for the user to gain the maximum amount possible from the media.

Making a design that is user-centric was also very important. One way in which to do this was to consider the user during the design process. First a requirements specification was drawn up, specifying who the users will be, what level of proficiency they have with technology, what devices they will be using the product on, who other stakeholders in this product might be, etcetera. It is also useful to create prototypes of what you want your user interface to look like and get feedback from potential users on this design.

There are four psychological principles of user interface design (Stone):

- **Users see what they expect to see:** new user interfaces should follow common layout conventions.
- **Users have difficulty focusing on more than one activity at a time:** User interface should remind user what they should do next.
- **It is easier to perceive a structured layout:** the screen should give visual clues as to what the functionality of interactive features are.
- **It is easier to recognize something than to recall it:** a user will find clicking an option easier than remembering a command.

It is easier for users to perceive a structured layout. Related information should be arranged so that it looks like it goes together. There are five Gestalt laws of perceptual

organization and grouping (Stone). These laws are guidelines that should be followed when presenting information on a screen.

1) The first is the law of proximity; this law states that elements that are close together appear as groups rather than random elements.

2) The second law is the law of similarity, which states that elements of the same shape or color appear to belong together.

3) The third law is the law of closure which states that, where possible, people see an incomplete element as complete.

4) The fourth law is the law of continuity which states that when there are small groupings of images that make a larger image, a user will view them as the larger image.

5) The fifth and final law is the law of symmetry which states that users tend to perceive regions bounded by symmetrical borders as coherent figures.

There are three principles to help ensure good human-computer interaction in relation to user interface controls (Stone). First the principle of visibility: it should be obvious what the control is used for. Second, the principle of affordance: it should be obvious how a control is used. The third is the principle of feedback: it should be obvious when a control has been used.

There are also several design principles that should be considered when putting together a virtual study aid. These principles are simplicity, structure, consistency and tolerance.

Simplicity stresses that the user interface should be kept as simple as possible. In order to achieve this, information should be presented as simply as possible and in the users' language. Icons, controls, words and actions should be natural to the users. Complex tasks or ideas should be broken down into simpler subtasks.

Structure is the design principle that emphasizes organizing the user interface in a clear and intuitive way. Items that the user associates as related should appear near one another on the page. Metaphors can be utilized to organize the interface in an intuitive manner; a trash can for moving garbage, a question mark for a help bar and so forth.

Consistency emphasizes the importance of uniformity in interface design. Consistency is especially important in the placement and behavior of controls within the user interface. For example, on every page of a web page or book the next button should always be in the same place. It should also always serve the same function. A customized style guide can help the designer in achieving consistency.

Tolerance is the design principle that accounts for the fact that the user is prone to making errors. The interface, however, should try to prevent the users from doing so. One way to make a user interface tolerant is to grey out unavailable options. In the example of modeling pages of a book, if you are on the first page the previous page button should either be grayed out or should not be included. If the user does make mistakes, the user interface should allow them to recover from these mistakes.

These principles of human-computer interaction were taken into consideration in the design of the virtual study aid.

Part V: User Experience

User experience is defined as human perceptions or responses that result from use of a product, service or system (Marcus). User experience includes all beliefs, preferences, perceptions and responses. Questions in user experience focus on what users do and why they do it (Marcus). This is relevant to this project because users should have a pleasant user experience with the virtual study aid. If students and professors respond well to the study aid then they will be more likely to use it and it will therefore be more effective. When considering user experience user-centric design is relevant. Relevant questions include:

- What are the user's intentions?
- What methods will the user use in interaction with this application? (Marcus)
- What are factors that would make use of the virtual study aid undesirable?

Considering the user experience leads to evaluation of the users. Some of the things that were considered are.

- What they information the students expect to be presented
- What kind of language the students expect
- What expertise the students have in interacting with technology.

These were some of the questions considered in the development of the virtual study aid.

Methodology

Once the group's background research had been completed and a strong foundation was laid it was time to make some decisions as to how to go about actually creating the study aid. Important questions had to be answered, such as:

- What platforms should we develop for?
- What style for displaying the information should we use?
- What do we need the study aid to be able to do?

Starting out with broad questions like these and continuing to refine the details, the group eventually developed an efficient toolchain/workflow for the creation of a study aid that addressed all of the principles deemed important from the background research. The following section is an account of the group's decision process, the final platform and tool selections, as well as how those tools were used in the development process.

It should be noted that the effort to create a virtual study aid for the WPI Robotics Department was not unique to the content of RBE 2001. Another group had previously been working to create a virtual study aid for the Introduction to Robotics class. Due to the similar goals of both projects, the possibility of collaboration was explored. Although the content of the courses vary significantly, both groups were able to benefit from each other's research in areas that overlap. Specifically, overlaps were identified in the research of development tools, effective means of deployment and the rating of effectiveness. Our group eventually met with theirs, ideas were exchanged, and their input was considered during the decision making process.

Part I: Development

It was important to first consider what functionality the virtual study aid required. Once this was done this set of criteria could be used to evaluate different potential platforms.

- **Deployability:**

  How many different types of devices does the group want the study aid to be available on, and how easily can the content be accessed on those devices by utilizing the tool?

- **Development Tools:**

  What features are natively supported by the tool as well as the target platforms for the project?

- **Features:**

  A list of ideal functionalities supported by the platform:

  - Interactivity
  - Videos/Images
  - Audio
  - Client-Server Communication/Cloud Based Operations

- **Maintainability:**

  How easy will it be to maintain/change the content of the virtual study aid in the future as the need arises?

These criteria were based upon the initial background research regarding what makes an effective virtual study aid. The following is an explanation of the features list covered

in the “Development” bullet list above that were considered for incorporation into the final product.

Interactivity: Interactivity is admittedly a broad and perhaps ambiguous term. To clarify, the goal is to have interactive figures which can be manipulated by the user. In this fashion the virtual study aid may be able to better assist the haptic learner. A hypothetical example of an interactive figure could be a drag and drop “linkage creator” in a section discussing linkage synthesis. Another example might be a circuit containing an operational amplifier wherein the user can change resistor values and observe the changes to the circuit’s output in real time. Possibilities for implementing interactive figures include support for Java Applets, or gaming engine extensions.

Videos/Images: For the visual learner, videos and images embedded in the virtual study aid address their particular learning style. Additionally, there are many concepts covered in the course material that are best described through visual means. The previous example discussing linkages again fits nicely here.

Audio: For the auditory learner, being able to listen to explanations of concepts could be a boon to their understanding.

Client-Server Communication/Cloud Based Operations: The ability for the study aid to communicate with a server or be hosted in a dynamic environment could be useful for three reasons. First, there is a possibility that the aid may be used to communicate performance data to the instructor. Secondly, the possibility exists that the aid itself may

be used as a forum for questions. Embedding a forum directly into the “chapters” of the aid allows students to ask questions on the material as they study, and receive answers either from the course staff or fellow students. Finally, depending on the platform, the possibility exists that content may be delivered to the aid “on the fly.” Essentially, this would allow the instructor to update the aid with new content as the classroom situation (i.e. progression through the course material) requires. Inherently, this would support the scaffolding and fading teaching methodology, as the aid’s content could be alterable to a limited extent at any time. (Jackson, Krajcik, Soloway) By supporting “on the fly” changes the instructor would have the ability to implement new content without needing to make major changes to the overall product itself. However, the benefits of these functionalities had to be weighed against the need for persistent or periodic connectivity to a network and the overhead of developing the necessary back end software required for it to work. It was deemed that while the benefits of client/server communication are many, the need for persistent connectivity would adversely affect the regular usage of the study aid and the additional development time would be too great for the scope of this iteration of the project. Thus it was ultimately removed from consideration.

Based upon how well each possible solution checked against this entire list of criteria, a decision was made as to which platform to utilize in the creation of the final product. The final criteria matrix can be seen below in Figure 3: Platform Functionality Matrix.

Figure 3: Platform Functionality Matrix

Platform	Interactivity	Embedded Video	Pictures	Audio
HTML5	Yes	Yes	Yes	Yes
HTML	Yes	Yes	Yes	Yes
Javascript	Yes	Yes	Yes	Yes
Flash	Yes	Yes	Yes	Yes
PDF	No	No	Yes	No
eBook	No	No	Yes	No
Interactive PDF	Yes	No	Yes	No

Based upon this matrix, there were many tools the group considered utilizing for development of the virtual study aid. These tools are both commercial and open source, and are capable of producing various types of electronic media. The following is the initial list of considered tools, and the output formats they support:

Adobe InDesign:

PDF, Extended PDF, EPUB, HTML5 (limited support)

Adobe Dreamweaver:

HTML, HTML5 (limited support)

eCub:

EPUB, MOBI

Calibre:

LIT, MOBI, AZW, EPUB, AZW3, FB2, HTML, PRC, RTF, PDB, TXT, PDF

eBook Maestro Pro:

EXE, HTML

The preceding list was by no means comprehensive, but provided an initial starting point for the group's investigation. The observant reader may notice a conspicuous absence of proprietary development tools (i.e. those specific only to iOS, etc.). This absence is intentional. One of the goals of the project was to be platform independent so that the study aid may be deployed to the largest selection of devices as possible. Limiting the study aid to a single device, or operating system, limits that selection significantly. It is for this reason that Flash and Javascript were not chosen as primary platforms for deployment, as they are being phased out on certain operating systems (that is, not natively supported).

Part II: Final Tool Selection

Adobe Dreamweaver

In order to develop the website for our interactive study aid the group used Adobe Dreamweaver. Adobe Dreamweaver allows both experienced web designers as well as beginner users to edit web pages. Once a template has been designed it is fairly simple for any user to edit the material in a web page and create new web pages. It allows a user to either edit using visual tool bars much like a word document, but it also allows an experienced designer to edit the HTML code directly.

It was important to choose a tool that both experienced web designers and inexperienced users could use to edit the virtual study aid. Even within the team working on the pilot virtual study aid some members preferred working with the HTML code itself

while others preferred the graphical user interface Adobe Dreamweaver provides. For this reason, Adobe Dreamweaver was considered to be the best choice for generating HTML documents.

GameMaker

The group met with Jim Monaco (a member of the ATC) to seek advice regarding the use of a tool called GameMaker. The group was referred to Mr. Monaco by our sister project, the RBE 1001 TextBook IQP. This project has been using GameMaker successfully to introduce levels of interactivity to their product. Additionally, their team had in their possession surplus grant money. Our group was able to utilize some of this money for the purpose of purchasing GameMaker licenses. Mr. Monaco gave us a broad overview of the capabilities of GameMaker and offered to be of assistance should we require any help with the tool.

GameMaker is essentially a graphical IDE which produces executables for both PC (x86 and x64) as well as the Mac platform. In addition to the graphical element of programming, it supports a proprietary scripting language dubbed GameMaker Language (GML) which is syntactically similar to Java. GameMaker is modular and supports a number of plugins. Of specific interest to our group was a class of plugins which allow export to a number of additional formats. These include Android, iOS, Windows 8, and HTML5. As one of our goals is to support many different end-user devices, this gives our group an even larger margin of flexibility for releasing our project.

Integrated SVN support, stability, regular updates and fast prototyping are all attractive parts of the software as well.

Having decided on the tool, the next steps were to acquire the appropriate amount and type of licenses, followed by determining the most efficient creative pipeline. Through multiple contacts with our sister project's advisor Professor Brad Miller, we were able to speak to the correct individuals for approval and file the necessary paperwork to tap into the RBE 1001 TextBook project's surplus funds and acquire five GameMaker licenses with accompanying HTML5 export plugins. A package deal was worked out for a grand total of $250. The HTML5 export plugins alone would have totaled over $1000 at retail price.

After much experimentation, a creative pipeline for producing interactive figures was developed. Initially, the raw content of the "chapter" of the text is divided into subsections and edited for readability. Once the text is finalized, a concept for the interactive figure is brainstormed. The interactive figure must summarize much of the core concepts of the text, and yet maintain continuity as a single object with a single theme to avoid any possible confusion by the end user. As such, given the software's namesake, the reasons for including interactivity in our project and previous research conducted in A-Term, it was agreed that each figure should take the form of a game. That is, each will have a goal of some sort that must be achieved by utilizing the concepts presented within the text.

Our first game titled “The Op Amp Game” has the user attempting to troubleshoot a robot. The concept is that a balancing bot is having difficulty maintaining an upright position, and you have determined the reason for this is an improper operational amplifier configuration. The game presents the user with five different operational amplifier circuits, in which the user must supply the missing elements in order to allow the robot to balance. If they enter the incorrect values for the elements, the robot will tip over. If they are correct, the robot will happily be on its merry way and the user has saved the day.

Although this game never made it into the study aid, its development laid the foundation for interactive figures to be included in future iterations of the product. The decision to omit the content from the study aid came after receiving feedback from the students (see the focus group subheading of the Results section of this document) stating that the interactive figures would be more effective if they were not in the format of a game. Therefore, future attempts at creating figures should simply be designed around demonstrating concepts and not have goals or objectives for the user.

Microsoft Visio

The text for the study aid was adapted from the lecture slides, and many of the figures from the lecture slides had been copied from various textbooks. It was therefore necessary to recreate figures so as not to violate copyright. For this task Microsoft Visio was used. Microsoft Visio is a 2D “drag-and-drop” drawing tool that is part of the Microsoft Office Suite. Visio is designed for the creation of flowcharts and other

diagrams which use repeating elements. This makes it ideal for the task of recreating figures of circuits, and served the group well.

Camtasia

Short instructional videos were created using Camtasia. As previously mentioned, videos are a powerful way to cater to the needs of the visual learner, and also allow for very hard to visualize concepts to be conveyed that students may otherwise have difficulty with. Camtasia is a video editing and capturing software that allows the user significant flexibility in creating videos. Some of the functionality includes splicing video, adding textual captions, effects (such as fades and wipes), voiceovers, and the ability to export to multiple video formats. As such, Camtasia was an ideal tool for final production of these videos. Among the videos produced there are examples of worked out problems, visualizations of complex motion, and useful background information for review.

Miscellaneous Tools

In addition to the tools mentioned above, there were several others that were used to supplement the creative process when it was appropriate to do so but aren't strictly necessary for creation of the study aid. For instance, Autodesk Maya (a 3D animation and modelling suite) was used for two of the videos. An additional miscellaneous tool was Microsoft Paint which was used when images needed to be touched up. Again, these tools were not strictly necessary but were used in the creative process nonetheless.

Part III: Implementation

Several pursuable avenues were available for the group to help decide exactly what content belongs within the study aid. The first avenue was the course content made available through lecture. That is, the course slides and reference materials from those slides. By utilizing the lectures as a basis for the study aid's content, the aid expands upon those topics covered in lecture with the hope that students may be able to reinforce prior knowledge of any topic that is introduced to them. Another avenue available to the group is the usage of assignments completed by the students as a basis for topics which may require more attention.

To that end, each assignment completed by the students was retained in an anonymous fashion. The course staff made copies of the relevant assignments and obscured each student's name. Then, they passed the assignments off to the group for analysis. By studying how the students performed on these assignments the group gained insight into the content which needs more focus in the virtual study aid. After looking at how well the entire class performed on all assessments priorities were established for the virtual study aid topics.

Content notwithstanding, its presentation needed to be addressed. Background research shows that presentation has a direct impact on the likelihood of retention by a user. (Landoni, Wilson, Gibb) In light of this, the presentation of the content must encapsulate the learning styles of all possible users; at least to the extent which is feasible given any limitations the platform imposed. Furthermore, the content must be

easily navigable. By adhering to these specifications the template of the format for the content of the study aid was developed.

Part III: Post Analysis and Evaluation

In order to analyze the success of the study aid, various surveys and a focus group were implemented. Surveys were embedded at the end of each page within the aid in the form of a Googledoc survey for ease of access. GoogleDoc surveys were chosen because they are free (unlike other services such as SurveyMonkey) and the results are easily accessible via GoogleDrive. These surveys asked students to rate how helpful each section of the study aid was, estimated time usage and asked for usage feedback.

The focus group gathered feedback from the students on improvements that could be made to each section of the study aid. The group followed ta standard format for conducting the focus group (for more information, see the Results section below). From analyzing this feedback the group was able to make determinations about how effective their methodology was, and how effective the study aid was as a whole.

Results

By applying the research on learning styles and electronic applications, the group designed an effective virtual study aid for RBE 2001. The group decided on a traditional website for the virtual study aid. This allowed for the use of HTML5 and Javascript to develop the aid. The group chose to use Dreamweaver to edit and design the website. A traditional website also allowed for the group to design a study aid that resembles a textbook and is familiar to students while also proving to be more convenient than traditional print formats and available on a multitude of devices.

The group utilized the knowledge gained from the research of learning styles and human computer interaction to properly design the virtual study aid. The group received positive reviews and evaluation from students by utilizing these techniques.

By analyzing the homework and tests collected and by applying research and speaking with course staff the group created sections of the virtual study aid based on topics students demonstrated difficulty with. With the implementation of the pilot virtual study aid the group gained feedback from both students and course staff alike on the presentation of the material.

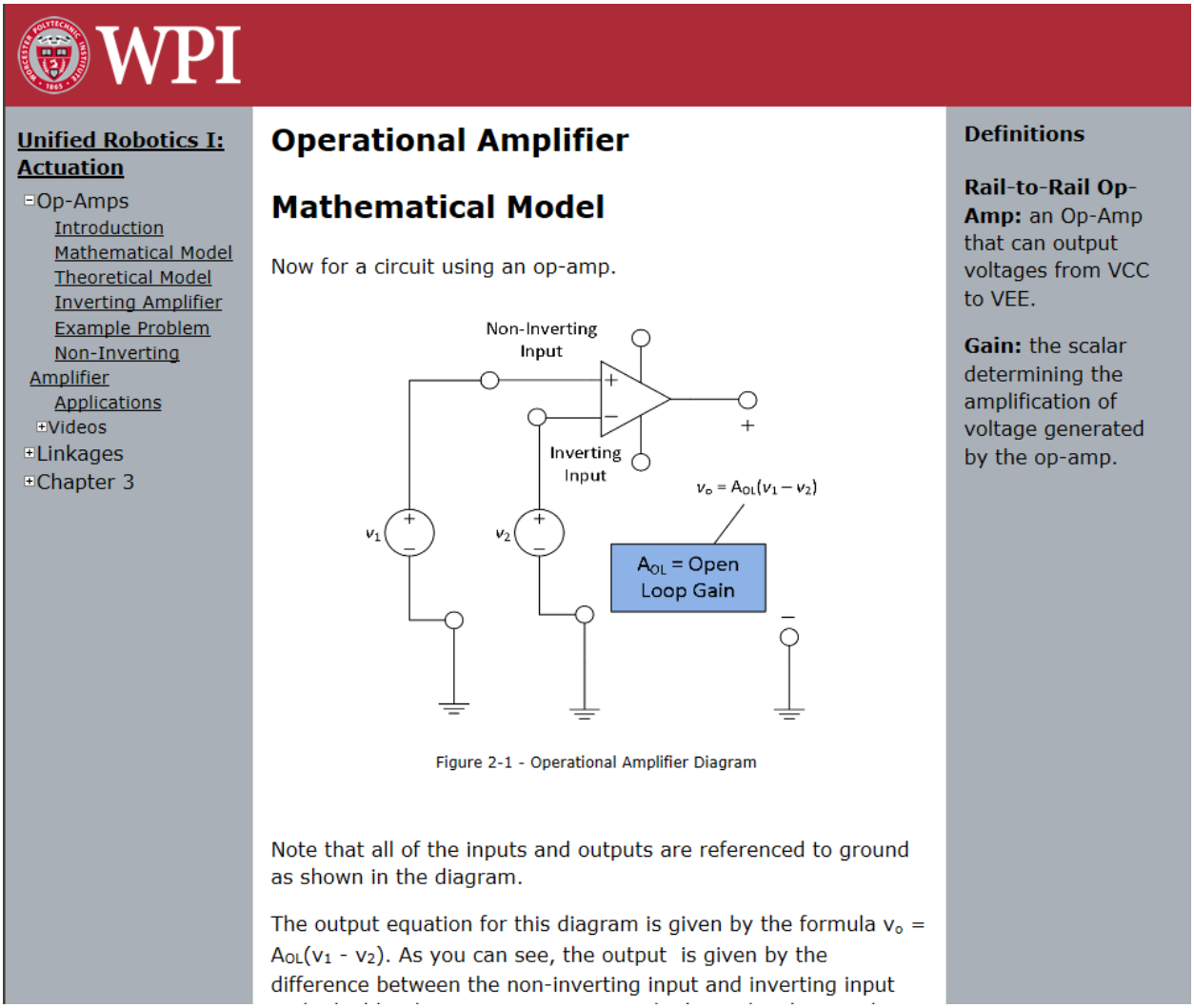
The pilot virtual study aid provides the basis for future projects. This will allow for continuation of a virtual study aid for not only this class but others as well, particularly other robotics classes at WPI.

Part I: Layout

The most important thing to consider when designing the layout for the RBE 2001 study aid was the students who would be using the study aid. It can be assumed that all users of this virtual study aid are and will be undergraduate students pursuing their bachelor's degree in robotics engineering or a related field. The text of the aid should be appropriate for undergraduate students who are approximately in their sophomore year. Since all of the students using this aid will be students pursuing highly technical degrees at WPI it can also be assumed that they are very familiar with traditional web pages as well as traditional textbooks. The aim of the design was therefore to fluidly incorporate elements of both a traditional textbook and traditional website to make this aid intuitive to students.

The layout of the aid was first created by hand on a piece of paper. A lot of thought went into the basic layout. The goal was for the aid to share a lot of commonalities with a traditional textbook, while being interactive. The layout we finally decided on was a middle area for text with two sidebars, one sidebar (on the left) for navigation and the other for definitions. The aid was also divided into chapters and sections, much like a textbook (see "Figure 4: Actual Layout of the Study Aid").

Figure 4: Actual Layout of the Study Aid



We chose this design because the sidebar navigation menu allows for ease of use in jumping from chapter to chapter and section to section. The sidebar for definitions mimics the classic sidebar for images and asides that many traditional textbooks incorporate. One of the most significant features of the navigation sidebar is the drop down tree. This format allows a user to navigate to any section of any chapter. This is an example of utilizing the benefits of electronic media. Like a traditional textbook however, the user may also press a next or previous page button at the bottom of each

section to make navigation while reading multiple sections in sequential order more fluid.

Another element featured in this textbook is the use of inline questions. These questions differ from a traditional textbook; they utilize interactive media. The answers to these inline questions are not immediately shown. As shown in the below figures, when a user wishes to see the answer they must press a button to reveal the answer.

Figure 5: Inline Question Before Expansion

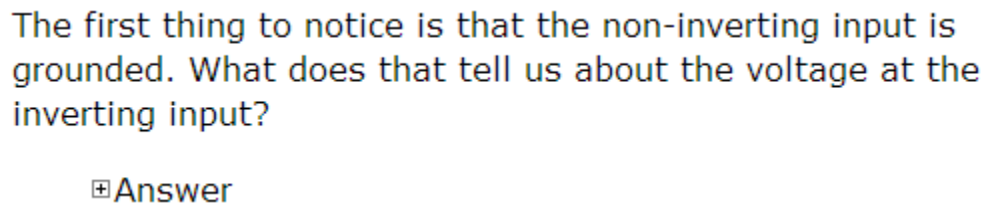
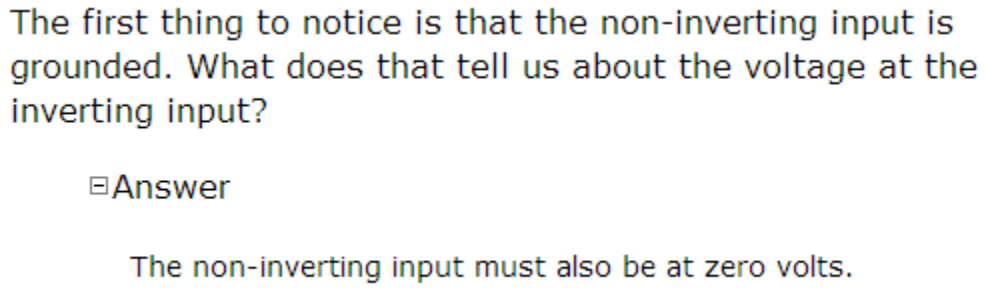


Figure 6: Inline Question After Expansion



The next question for the team to address was whether to use a fixed, fluid, or hybrid layout. In an entirely fixed layout each section width is determined by a designated number of pixels and will always stay the same regardless of the screen size it is viewed on. In a fluid layout, the sections change size and text reflows depending on the size of a screen. A popular example of a fluid layout is Wikipedia; this example

however, has little interactivity. Both layouts were considered and implemented. The team decided on a fixed layout. A fixed layout is simpler to implement than a fluid one. It is also difficult to ensure that text and images will stay aligned in a fluid layout after resizing. Due to the fact that images, videos and interactive figures are important components of this aid and their positional relationship to the text is also important, the fixed layout was chosen.

Part II: Writing the Text

The instructional text for the aid needed to be written by someone with expert knowledge of the subject material of the RBE 2001 class. As the team currently working on this project are all still undergraduate students who recently completed this course, it was more suitable for another party to provide as much of the content for this text as possible. The professor for this class used a speech recognition program to record his lectures and transcribe them. The team then was able to go through each lecture, and act as editors to ensure that the flow was appropriate for a text-based lesson.

Part III: How-To Guide

The team also completed a how-to guide (submitted as a part of the eCDR) that details the process for creating the aid. This will be useful in helping future groups and professors develop new material for the aid. This guide contains step by step instruction of how to use the tools involved in creating this aid. Screenshots as well as descriptive text are used to help the reader understand the steps involved this process. It is the hope of the group that the aid continues to grow after this project. This how-to guide is vital to success in future groups working on the aid.

Part IV: Analysis of Quizzes

In order to find the most important part of the aid to complete first, several quizzes were analyzed. Data on quiz grades from the Unified Robotics 1: Actuation class was collected and analyzed. This was done on the basis of each question rather than each quiz. This was done because different questions on the same quiz covered different topics. The class average of each question was calculated and a bar graph of all the averages was made (see Appendix A: Aggregated Quiz Results). The Unified Robotics 1: Actuation class scored the lowest on quiz five question three. This question deals with Thévenin-Norton Equivalent Circuits. This chapter now has a high priority for the aid.

Additional quizzes were analyzed. This information was used to further determine where to focus on the aid. The average of each question was taken and graphed using a bar graph. Question four of quiz three was an extra credit question and therefore all students did not attempt this question. Students struggled with a question which had to do with energy stored in a circuit. The quiz two results were also bimodal. This means that some students did well on this quiz and others did not do well. This could possibly be because the class was taught in a manner that appealed to certain learning styles or some students were more familiar with the material.

The information from these quizzes gives a good basis for further research into the effectiveness of the virtual study aid.

Part V: Feedback

On February 21st the team held a focus group for current students of the class. The goal of the focus group was to ascertain the effectiveness of the study aid as a resource and garner feedback regarding how the aid may be improved. The students had been given access to the aid in time for the class's series of lectures involving operational amplifiers, which marks the first time the aid had been used in conjunction with the standard class materials.

The focus group was held at 9:00PM on a Thursday. The decision to hold it at this time was deliberate; by observing the occupancy of the robotics lab at any given time the team was able to conclude that throughout the week this particular time block would yield a large number of students. This time period, in conjunction with the promise of free pizza for attendees, managed to yield 14 RBE 2001 students (a significant sample size given the total class population). Of the 14, two students had participated in a focus group (or equivalent meeting) in the past.

The meeting was prefaced with introductory information. The following is a short excerpt from the meeting's transcript:

"*As you all know, the RBE courses currently do not have any textbooks. On one hand this is fantastic, but it can really be a hindrance when you don't understand something and need another resource to refer to. The current options are very limited: you can*

chase down textbooks from ECE, ME or CS to try and answer a specific question, but finding information this way can be difficult as these books are not written with robotics in mind. Also, many of the things we try to do are a combination of two or more of these majors, which makes hunting for specific answers all the more difficult. What we're trying to do is create a useful resource in lieu of a textbook that will actually be useful to RBE students. What you have seen on the web is our first crack at this, and we need your feedback to make it better.

Now, we know that there are a lot of improvements that can be made. We'll be taking notes on the discussion as it flows. It's important that you know that we are not collecting any personally identifiable information, so feel free to say whatever you want about anything you want … don't worry about offending us. That being said, honest criticism and constructive feedback will be much more useful than just stating 'the aid is bad'..."

Additional information was given to the students on how a focus group is conducted as well as a note on respecting each member's opinion. After the discussion leader was satisfied everyone understood the meeting's purpose as well as the ground rules, the discussion commenced. A complete record of the main questions may be found in "Appendix B: Focus Group Questions" at the end of this document.

Overall the students were very pleased with the study aid as an additional resource for their coursework. Due to the nature of the confidentiality of the focus group, the

students' responses will be paraphrased within this report. However, as much information will be provided as possible.

Regarding the layout and interface:

- The students approved of the Chapter/Section layout provided by the aid, as the smaller sections allows for information to be accessed more directly. Additional subheadings would be desirable, but not necessary.
- A search feature would improve the ability to quickly and easily ascertain which Chapter/Section the students need to refer to.
- The students believe the layout is easier to navigate than an e-book (or equivalent) document.
- The overall look and feel of the interface is simple and effective. Adding more "flash" would be a mistake.
- The definition section was extremely helpful.
- The collapsible navigation bar was useful but should be redesigned to not collapse in between each page navigation.

Regarding the general content:

- Links to external content (such as the relevant Wikipedia page) would add to the overall quality of the content.
- Pre-made citations for specific pages on the aid would be useful for referencing the aid.
- A chapter summary/review page would be useful for studying for exams.

- A chapter dedicated to practical knowledge information is highly desirable. Practical information would include instructions on how prepare files for use with the laser cutter, tutorials (such as how to solder), where to purchase materials such as acrylic, and guides to using some of the common software tools (a.k.a. PuTTY, Linkages, Solidworks). Links to pre-existing guides would be an acceptable alternative to in-document guides.
- If a particular concept is introduced but not explained, mentioning the course in which the concept will be covered is desirable.
- Additional inline questions (i.e. “Show me the answer” style).
- Whenever possible, equations should be “called out” by either using equation generating software or by differentiating them with bolded text and differing colors.

Regarding example problems:

- The given examples are easy to understand and helpful.
- More example problems would be desirable. Specifically, problems catering to more levels of understanding; from extremely simple to very complex.
- When creating an example, it is always desirable to include as many steps as possible. Incorporating the expandable format for these steps would be appreciated.
- Many students expressed interest in example problems taken from class but approached in a different way to aid in understanding.
- Students also expressed interest in somewhat unrelated examples. For instance, how you might use an operational amplifier in an audio circuit. The rationale for

this being that becoming familiar with the operation or behavior of a circuit element in a variety of settings would increase preparedness for encountering the element in unfamiliar situations. This can be extrapolated beyond operational amplifiers to include other concepts as well.

Regarding the media beyond simple text:

- The figures are easy to understand and helpful. No changes necessary.
- Audio transcriptions of the text would be useful, but should be of a low priority.
- The videos are useful. Short lengths are desirable, as well as covering only a single topic per video.
- Videos of hard to visualize concepts (i.e. different formations of linkages) as well as their practical applications are highly requested.
- The students were highly enthusiastic over the idea of interactive applets. Generally, they should be in the format of “sandboxes” rather than games with a defined goal.

Regarding additional feedback:

- The students expressed an extremely strong interest in a programming section of the book. This section would include basic tutorials (i.e. data types, simple control structures, pointers) as well as more complete code snippets for common tasks (i.e. serial communications, interfacing with sensors, etc.). These codes snippets should contain highly detailed comments for understanding.

- Having the document in a portable format would be desirable for use on tablets and other devices given that studying may happen in areas without internet access.
- Examples of old tests and quizzes would give the students a better idea of what kind of problems to study for in upcoming quizzes and exams. Along these same lines, examples of outstanding past projects come highly requested.
- The addition of a directory of on campus resources and common contact information.

Based on the large amount of participation and feedback, the group judged the focus group as a success. The team was excited that the response to the aid was so overwhelmingly positive, as evidenced by a common lament heard throughout the night; that a linkages section would not be finished in time for their final exam as the operational amplifier chapter was so useful. Although our team will not be able to implement many of these suggestions given that the development period for the aid has expired, these suggestions can and will provide a useful roadmap for future IQP teams to follow when continuing work on this resource.

Challenges

The team experienced many hurdles and challenges in the course of the project. These came in different forms such as the unexpected overhead in research required for this project, development time, delays due to bureaucracy, and learning new software. This section will delve into some of the issues the group came across.

Part I: Institutional Review Board

The purpose of the Interactive Qualifying Project is to study the social implications of technology. Throughout this project specifically it was necessary to have human test subjects. The first hurdle that the team experienced was permission from the Institutional Review Board (IRB) to use quiz results from the RBE 2001 class for research. It was necessary to get in contact with the IRB as the team would be collecting and storing anonymous quiz results. The team applied for an exemption form as this project fell under the category of research that could likely get exemption from the IRB. The permission to use these quiz results did not come until the latter part of B term. This was a problem because the team needed to analyze the results to decide which section to complete first. The way that the team managed to overcome this hurdle was to take into consideration past experiences in the RBE 2001 class and ask Professor Putnam, who teaches the class, where the most problems lie and made a prediction about which chapter would be the best to start with. The team also ended up starting with a chapter that no test results were supplied for. Future groups will still have to deal with acquiring IRB permission to collect data, but this should stand as a warning on the delays it may cause or readiness a group may require.

Part II: GameMaker Licenses

Another challenge the team faced was acquisition of the GameMaker licenses. To export GameMaker to HTML5 there was an additional license required. The RBE 1001 IQP group had a grant to create their virtual textbook. For this project permission was sought to use some of that money to purchase licenses. There were many people who the group needed to communicate with to gain access to this extra feature of GameMaker. The project was delayed while waiting for the purchase of these licenses to be approved. The team ended up not using many GameMaker features due to this fact. These licenses will be useful in improvements and continuations of these projects.

Part III: Learning New Software

Much of the software being used for this project was unfamiliar to the team. It was therefore necessary for the team to familiarize themselves with the software. First the team had to schedule meeting times with ATC staff to undergo a quick tutorial on how to use the software. There were many mistakes and difficulties with creating the first chapter of the study aid due to the learning curve of the chosen tools. After the first chapter, however, chapters were easily finished as the template was already developed and the team was more familiar with the software. Because the layout of the RBE 2001 virtual study aid is now complete, and a How-To Guide has also been developed, future groups should easily be able to edit the study aid, allowing for an easier transition into the software.

Conclusion

This project served to set the foundation for the development of the Unified Robotics 1: Actuation Virtual Study Aid. Even with the many unexpected hurdles in the project the group managed to use the knowledge gained through research to appropriately design a Pilot of the intended Virtual Study Aid, from its content to its development process. Other research into similar available online learning tools and applying the principles of human computer interaction also affected the content, and the presentation, of the Virtual Study Aid. Then this research was applied to the development of the study aid, the result of this is a web page with a navigation bar similar to many other websites and content very similar to that of a regular book. HTML5 support all criteria and was chosen as the platform for the development of the website, Dreamweaver was chosen as the development tool to accompany the platform due to its availability on campus. After development, the Virtual Study Aid was implemented and a focus group was used to gather data.

With this research and the feedback from the developed Virtual Study Aid the team can answer the focus question “In the development and implementation of an virtual study aid, specific to the content of RBE 2001; --what would be the most effective method of presenting the material?” With the overwhelming positive feedback and demand for more sections of material be added from the focus group, as well as positive feedback from the staff, the developed Virtual Study Aid was a very effective form of presenting the material, this will be further addressed in the results section of the conclusion.

Many initial decisions and designs were incorporated throughout this project. The basic template for the virtual study aid was designed. The format for questions as well as interactive figures and videos was determined. The order in which to complete topics of the RBE 2001 class was also determined. The way in which to convert the lecture slides into appropriate material was decided on, and licenses for GameMaker were acquired. The hurdles that were overcome this term took much time, but a subsequent IQP team should not encounter the same hurdles a second time.

Part I: Initial Research

The research done into learning styles proved to be the most valuable when making considerations of what type of material to implement. With this knowledge, informed decisions could be made on which content to develop in order to improve the RBE 2001 classroom experience via the Virtual Study Aid. From this it was decided that Print would see the most significant improvement. This material also helped the choose desired features necessary for the development platform.

The final desired features of the platform were support for interactivity, ability to embed pictures, videos and audio, as well as client/server communications. Also taken into consideration was the number of devices that support the platform; this proved to be a significant measure as it provided a sense of availability. These also reflect many of the features found in other existing online learning tools that were looked into. In using these features the principles of human computer interaction were used to develop a layout that was simple to use and familiar to the user. The resulting layout was very

similar to a textbook with textbook like features, but taking advantage of the interactivity present in a web page.

Part II: Development Process

The Virtual Study Aid for RBE 2001 was developed first by applying knowledge gained through research into the learning styles and human computer interaction. Further research into already existing online learning tools also provided with many ideas of where to start and features to add.

The original layout was first sketched and taken through a revision process. These layouts and revisions were presented to the project advisors and discussed internally amongst the group. Feedback was taken into account in each revision.

The content present in the Virtual Study Aid was an adapted and edited form of the content provided by Professor Putnam. This provided for accurate content and lessened the burden on the group on generating its own content.

This development process proved to be very efficient, it allowed the group to focus on how to display the content while only having to generate very little and only adapting most of it. This also provides material very similar to what is already present in the classroom but in different form. With the use of HTML and HTML development tools the time required for development can be significantly cut down, and in some cases fixing bugs can be done with nothing more than a text editor.

Part III: Results

With the lack of data collected from the surveys present in each page the only results were the ones obtained from the focus group. Given the overall response of the students wishing for more content and lack of complaints about the layout or the way the material was presented, it is safe to assume that the material was presented in a very effective manner. This can be further enforced by the positive feedback given by staff. However the focus group also provided many examples of features that could improve the Virtual Study Aid.

With this large amount of positive feedback, and with further analysis of the produced study aid using the knowledge gained from the research, it was concluded to be a success and helped answer the focus question. “In the development and implementation of a virtual study aid, specific to the content of RBE 2001; --what would be the most effective method of presenting the material?”, the answer to this question would be that the material should be displayed in a manner that enforces what is learned in the classroom while providing other learning styles that are not as prominently focused on in the already existing classroom and lab environment. The additional material should be in the form of classroom lectures transcribed to text with the figures that accompany it, videos of problems being solved step by step, scaffolding problems, links to outside sources with accurate material, and interactive exercises in an easily accessible website format. It is advised that in future projects other means of incorporating additional learning styles, or further enforcing the ones already present, be looked into, as this is not a complete list but rather the features that were researched and decided to be included.

Part IV: Discussion

When this project first started the intent was to develop a virtual study aid encompassing all of the material covered in RBE 2001. After the first couple of weeks it was quickly realized this goal could not be met in a satisfactory manner. However the team has determined that although only two sections were produced this project serves as a great pilot, not only for Unified Robotics courses but hopefully for other courses as well.

As was stated before the group did not expect the amount of overhead required to begin the project and delays that it met along the way. Because of these issues only two sections were produced, and certain functionally originally intended for the virtual study aid was not implemented. However this project leaves behind a great deal of setup that needed to be done, so future groups may not face as many hurdles in starting. This project also leaves behind a How-To guide to speed up the acclimation process to the software used in development of the virtual study aid.

Moving forward, the amount of development time per chapter should be less. It is much easier to insert information into an already designed template than to both design a template and add information to the template. There is also a possibility that the style of interactive practice problems will be similar and it will be possible to use the current interactive practice problems as a starting point for the design of future practice problems.

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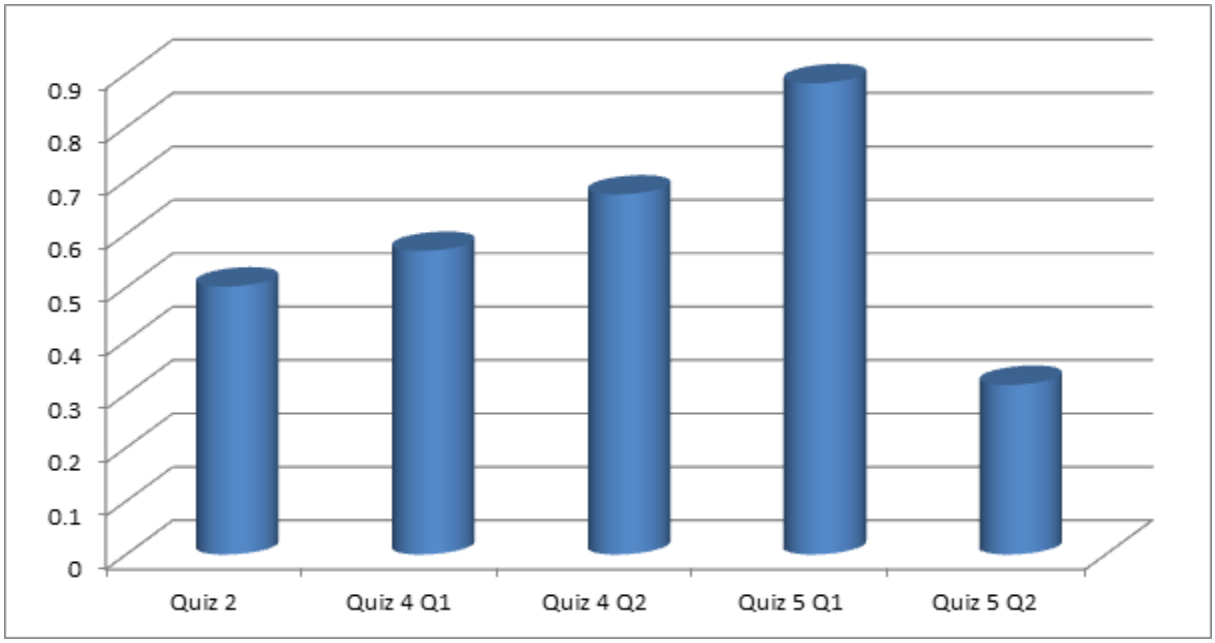
Appendices

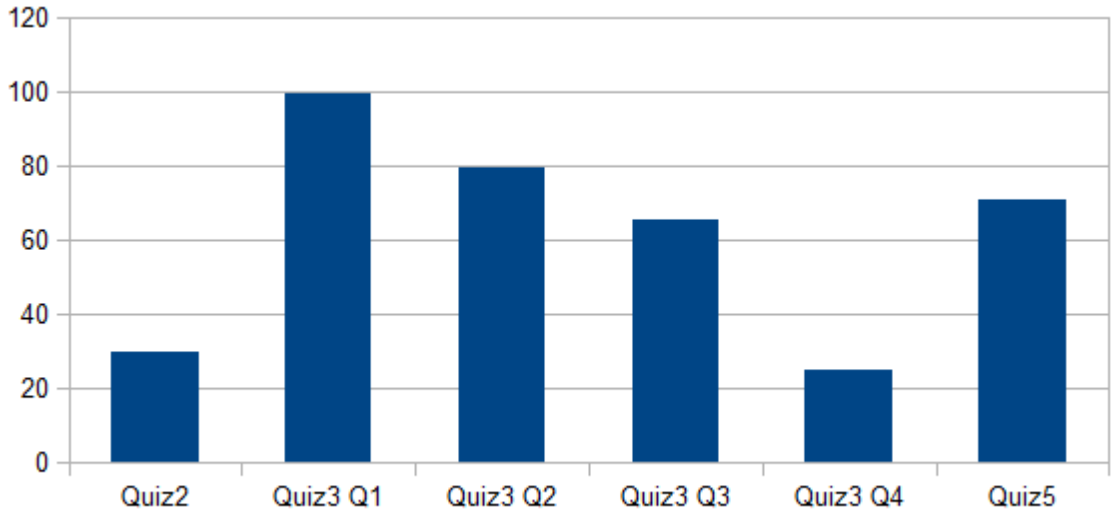
Appendix A: Aggregated Quiz Results

Figure A1 – Quiz Results – A Term



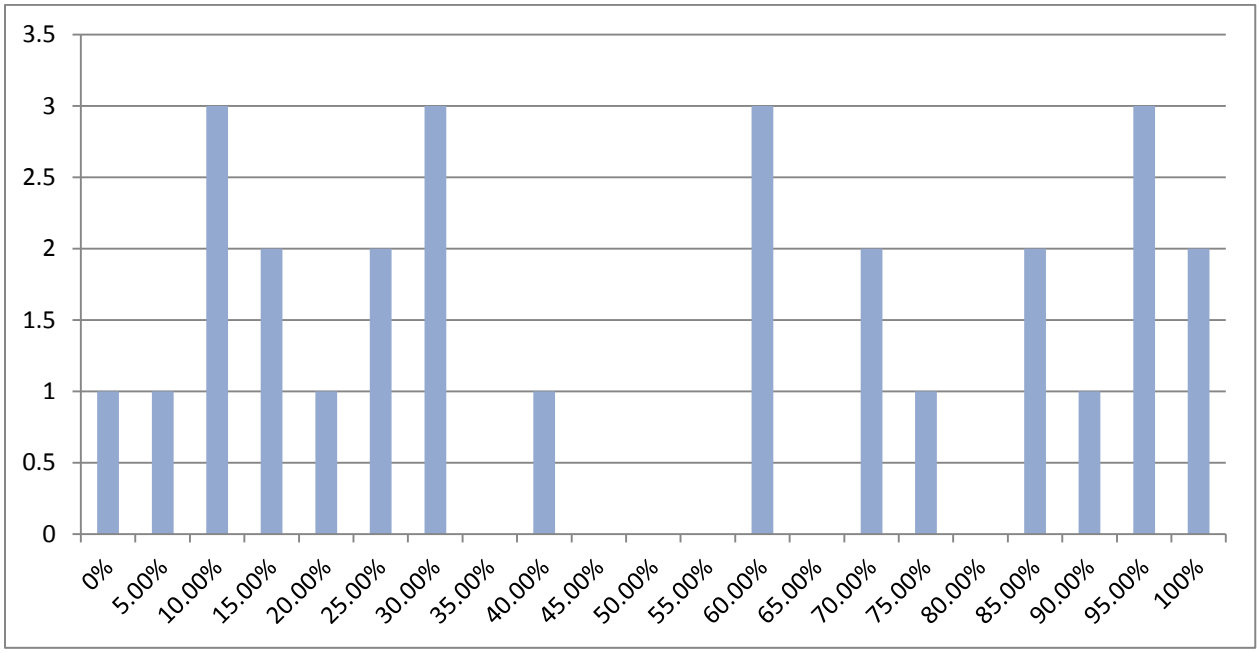
Bar graph of questions from three different quizzes from this graph it is evident that the worst performance was on question 2 of quiz 5.

Figure A2 – Quiz Results – C Term



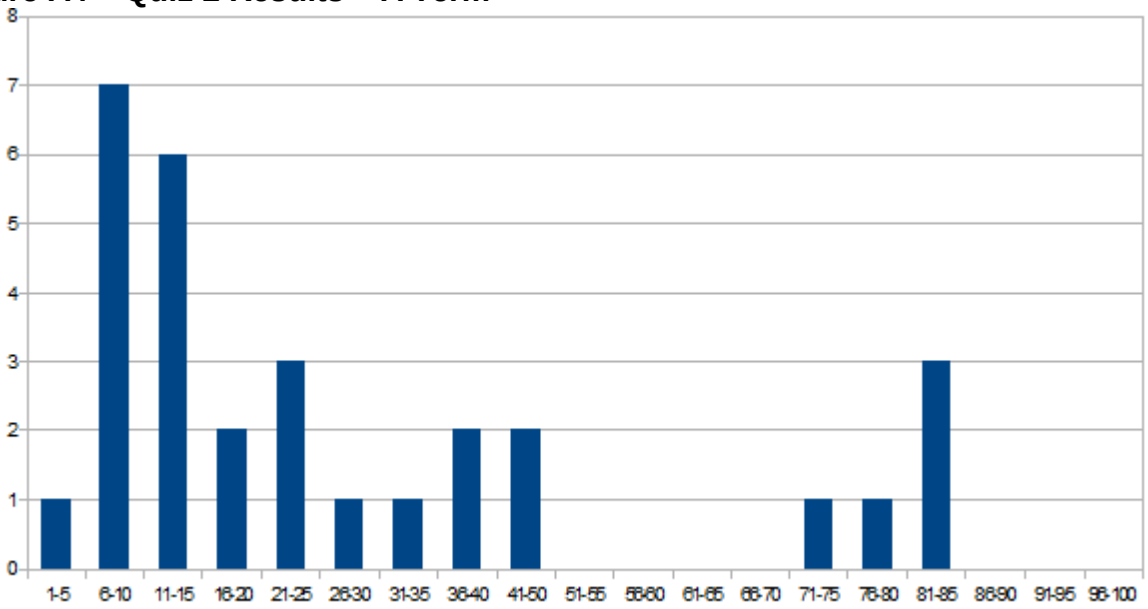
Bar graph of questions from three different quizzes from this graph it is evident that the worst performance was on question 4 of quiz 3.

Figure A3 – Quiz 2 Results – A Term



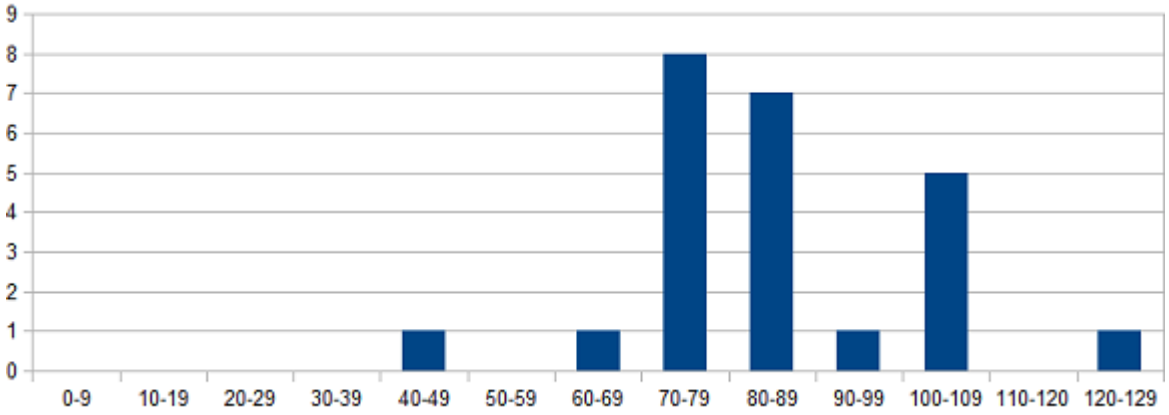
Bar graph of the results from the second quiz, this graph is bi-modal. Students tended to understand the quiz question or did not. This subject of this quiz was energy and, capacitance, resistance and inductance

Figure A4 – Quiz 2 Results – A Term



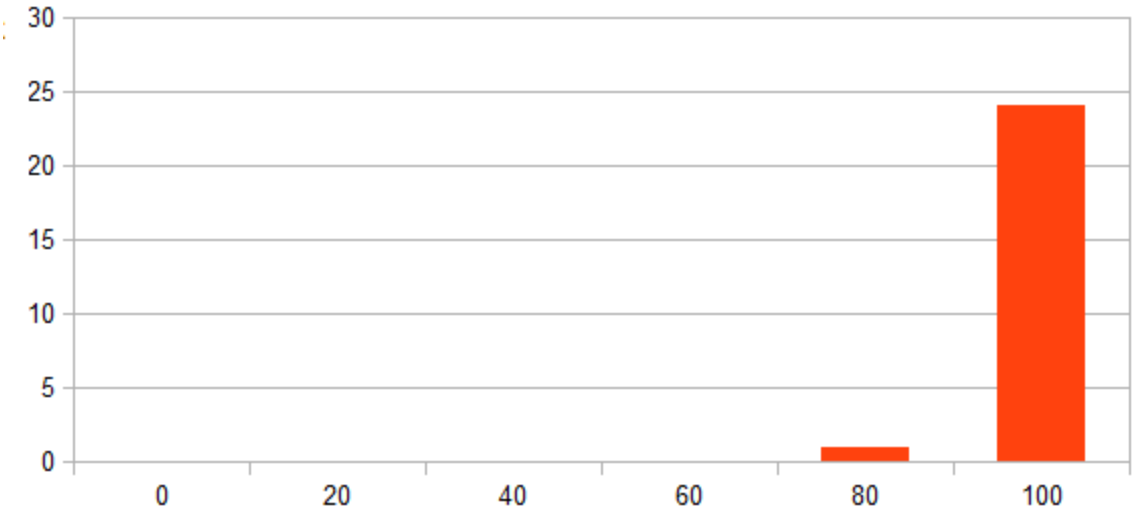
Bar graph of the results from the second quiz, this graph is bi-modal. This graph shows a trend similar to the A-Term class

Figure A5 – Quiz 3 Results – C Term



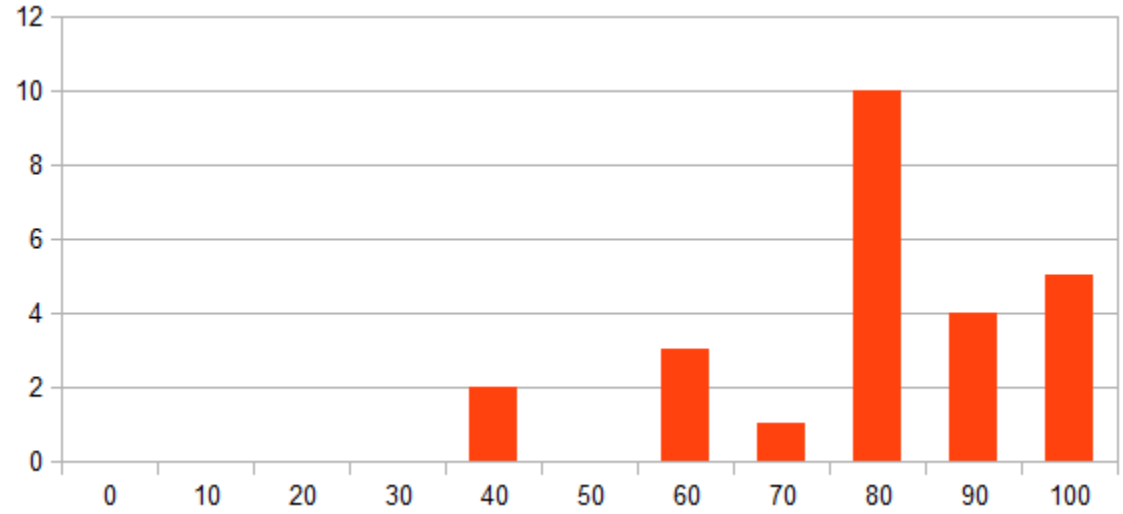
Results of the third quiz, which related to motors. The class did fairly well on this quiz

Figure A6 – Quiz 3 Question 1 Results – C Term



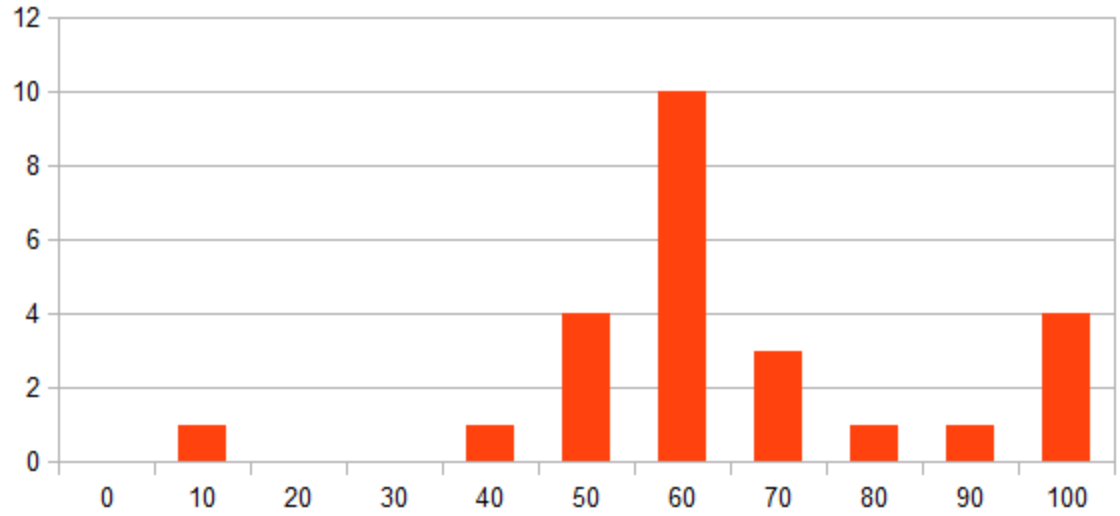
This question was about motors, loads and EMF. The class did very well on this question

Figure A6 – Quiz 3 Question 2 Results – C Term



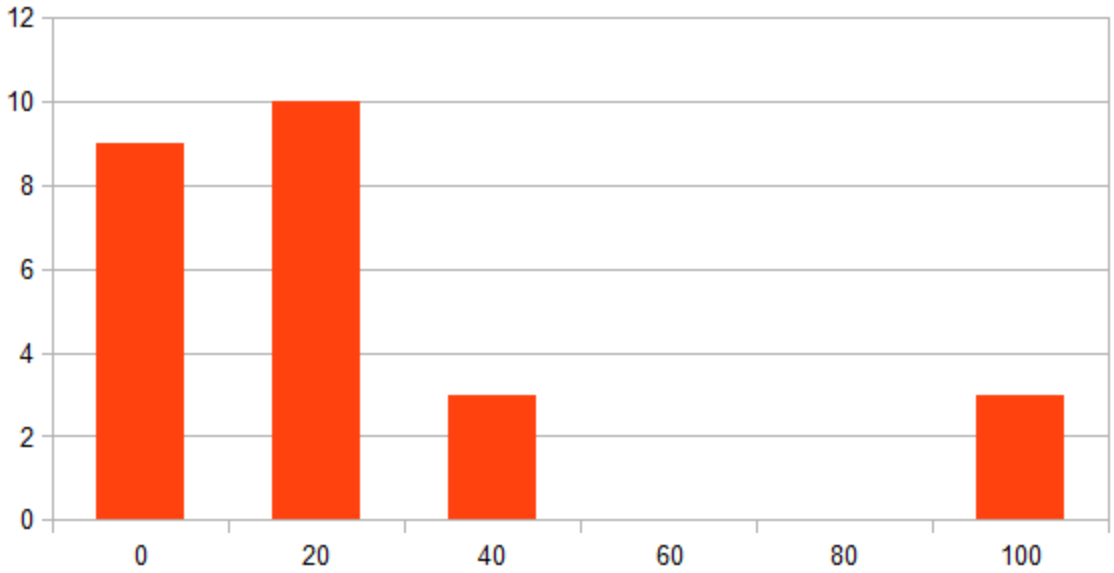
This question was about EMF. The class did fairly well on this question

Figure A7 – Quiz 3 Question 3 Results – C Term



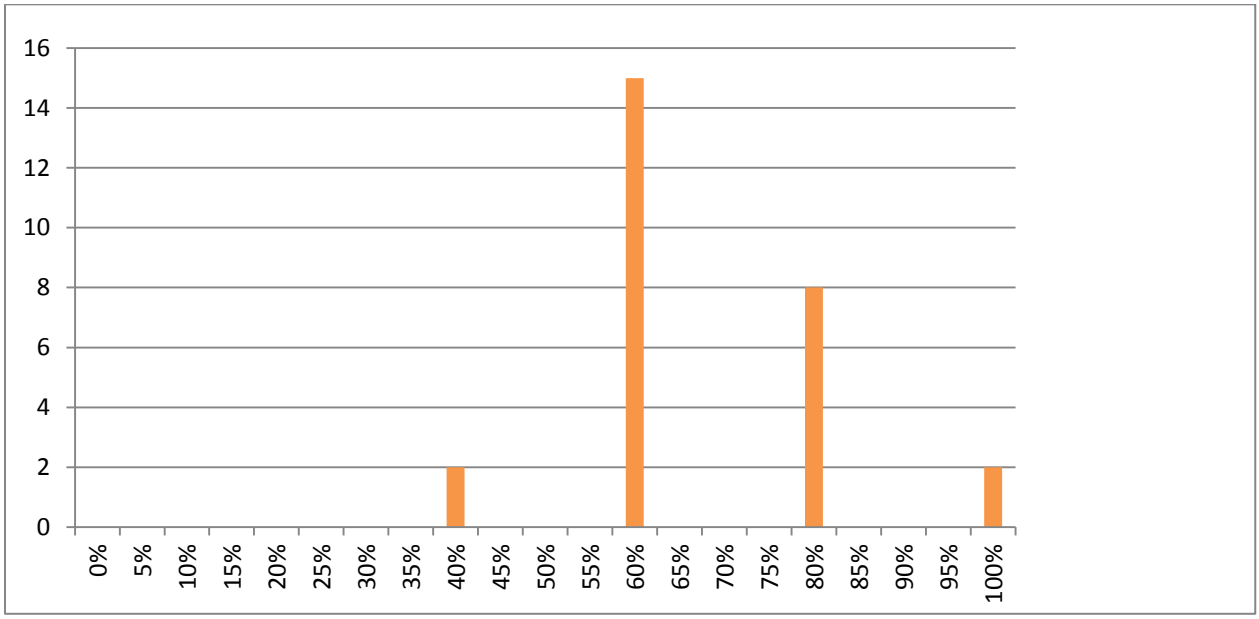
This question was about motor speeds and torque. The class did okay with this question

Figure A8 – Quiz 3 Question 4 Results – C Term



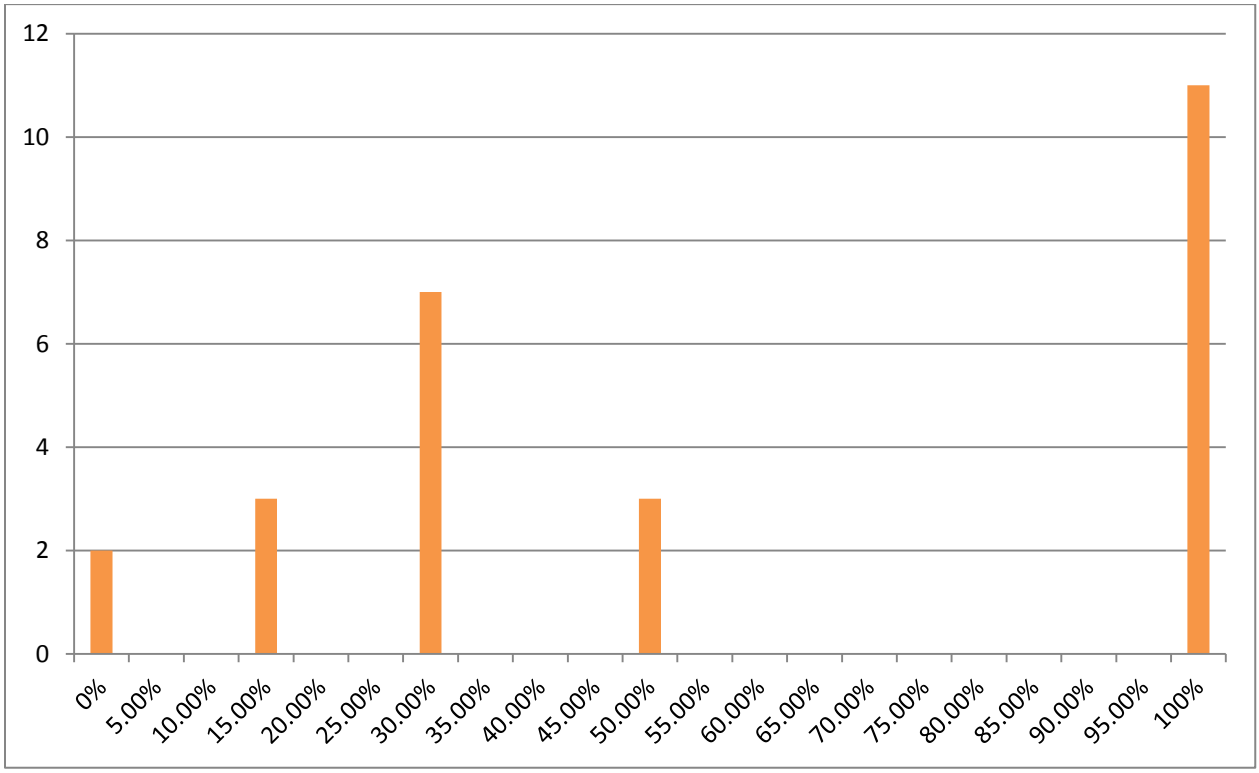
This question was extra credit and probably should be discounted

Figure A9 – Quiz 4 Question 1 Results – A Term



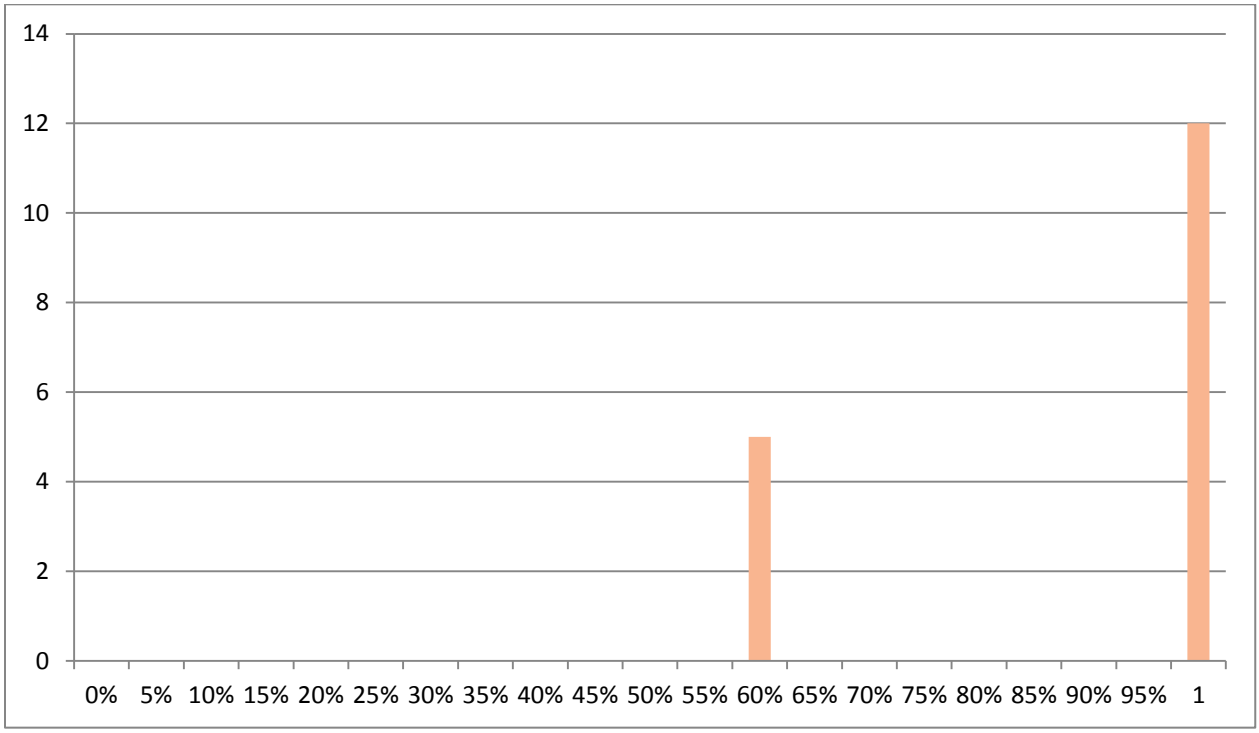
This question was on position analysis. The students did well on this question, and there was a reasonable curve for this question.

Figure A10 – Quiz 4 Question 2 Results – A Term



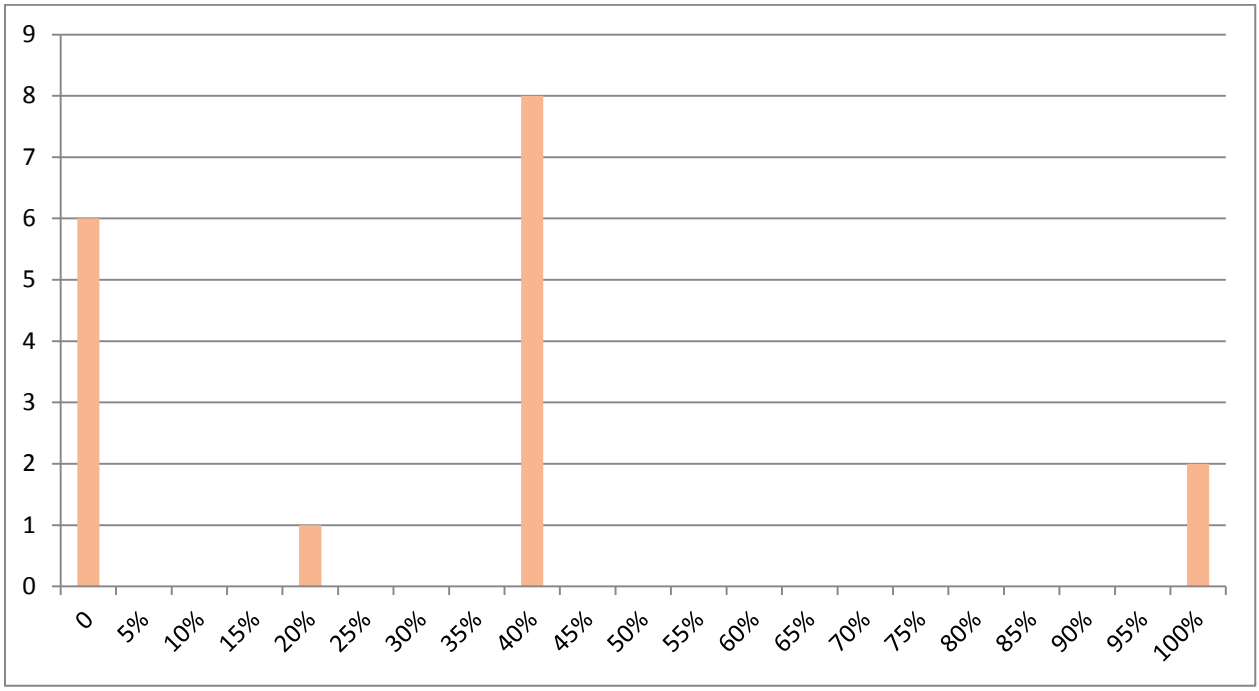
The subject of this question is polling versus interrupts. The results of this quiz had a bimodal spread.

Figure A11 – Quiz 5 Question 1 Results – A Term



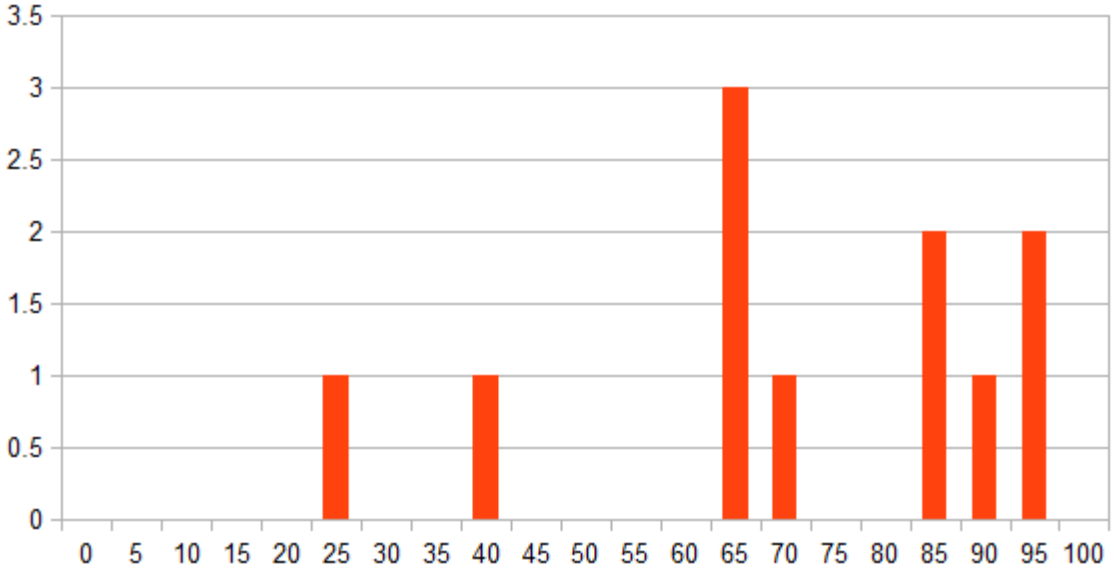
Quiz 5 question 1 was on Thevanin and Norton equivalencies.

Figure A12 – Quiz 5 Question 2 Results – A Term



Question 2 of quiz 5 was also on Thévenin-Norton equivalencies. The students did very poorly on this question with the exception of a select few.

Figure A12 – Quiz 5 Results – C Term



This question was about circuit analysis. The class did fairly well on this question

Appendix B: Focus Group Questions

1. Currently the website is separated into chapters and sections. This was a conscious design decision. When you used the website, how easy was it to find information you were looking for and how did you feel about this layout?
2. Are there any suggestions about how to make it easier to find the information you need?
3. When you found the section you were looking for, how good was the information you got? Was it easy to understand? Was it relevant?
4. There are a number of examples worked out for you. How relevant were the examples?
5. Were they easy to follow? Hard to follow? Too easy? Just right?
6. How about the pictures? Were they useful?
7. Would you want more pictures? Less? Or is it just right?
8. We are trying to include additional kinds of media other than just text and figures. Right now there are a few videos on the website. How were the videos?
9. Would you want more videos? Less? Or is it just right?
10. How about audio recordings. Would an audio transcript of the text be useful to you?
11. We have also explored the idea of using interactive figures. Think HTM5 and flash type applications. How do you feel about that?
12. Would having these be more useful or less useful in a game format?
13. Lets switch directions for a second. Keep in mind that we want the website to be as accessible on as many devices and platforms as possible. Knowing this, how can we make the website more attractive, but still keep it functional?
14. Honestly, how much did you use the site after the professor released it to you? Any particular reasons why or why not? We won't be offended.
15. Other than the suggestions we've already discussed, is there anything else you would like to see changed? Anything that would make you use the site more?
16. Any other feedback for the team?

Appendix C: Authorship

Section	Contributors
Abstract	Jessica Gwozdz , Olivia Hugal
Executive Summary	Jessica Gwozdz , Olivia Hugal
Introduction	Jessica Gwozdz , Olivia Hugal
Background	Jessica Gwozdz
Methodology	Christopher Conley
Results	Christopher Conley, Olivia Hugal
Challenges	Gilmar Da Vitoria
Conclusion	Gilmar Da Vitoria