Online Physics Experiment

by

Safwan B. Abu Hassan

Dissertation submitted in partial fulfillment of

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(Information and CommunicationTechnology)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the

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in partial fulfillment of the requirement for the

BACHELOR OF TECHNOLOGY (Hons)

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Approved By,

....

(Dr. Wan Fatimah Wan Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2008

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in the project, that the originality work is my own expect as specified in the references and acknowledgements and that the originality work contain herein have not been undertaken or done by unspecified sources or persons.

.........../........

(Safwan B. Abu Hassan)

ABSTRACT

The current implementation of traditional hands-on laboratory work is limited by the physical constraints of both time and space. Besides that, other concerns such as inadequate equipment and safety hazard of laboratory work are also deterring the effectiveness of the experiments. An online experiment is aimed to provide an alternative approach in implementing laboratory experiments where students can participate interactively and experience physics theories just as they would be taught by textbooks, lectures and labs. Besides that, this project will also lift the limitations faced by the traditional laboratory work. The targeted user for this project ranges from high school students up to university students taking introductory physics courses. The experiment contents were constructed based on basic and simple physics experiment and activities that will provide users with the understanding of the physics concept being taught. Meanwhile, the development of the online laboratory is using Adobe Flash and the World Wide Web technology as the platform. A learning theory is followed in order to ensure meaningful learning process takes place. Usability aspect of the system is also given priority in order to develop a user-friendly environment. ADDIE development methodology was followed in the development of the whole system that ensures effective learning process takes place by giving learners what they need. By integrating an excellent pedagogical concept, proven methodologies, interactive multimedia application and web technology, the online physics experiment provides a whole new level of education.

ACKNOWLEDGEMENT

'In the name of Allah, Most Gracious, Most Merciful'

First of all, I would like to express my deepest gratitude to the Almighty Allah for the blessing and guidance for me to successfully complete the Final Year Project.

There are so many people who have been an inspiration to me in completing this project and who have provided encouragement and support throughout the duration.

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This acknowledgement is also dedicated to my fellow friends and UTP lecturers who have continuously motivated me that it was possible to achieve such feats. Last but not least, to my beloved family and especially my mom, Nor Aziah Lazim, thank you for being such a patient and wonderful mom. I wish a lifetime of happiness and may Allah bless you all. Once again, thank you.

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ABBREVIATIONS AND NOMENCLATURES

HTML   Hypertext Markup Language
PHP   Hypertext Preprocessor
CSS   Cascading Style Sheet

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The use of computers and multimedia, as well as the internet and new communication technologies allows new forms of teaching and learning such as distance learning, virtual simulations and many more. Student laboratory work is seen as essential part of the study of introductory physics at every college and universities. One of the goals for laboratory work is to give students more understanding to the theories that they have learn in lectures. In this project, both the lessons taught in class and the experiments done in laboratory will be combined and put in multimedia format that can be accessed via the internet.

With the use of multimedia and web-based technology in education, there comes a new problem. Usability of software's design and structure is an issue faced by the users and it is the developer's responsibility to ensure that their software is easy to use. As transferring from traditional method of laboratory work to a virtual environment aims to alleviate problems, a system with usability problem would only defeat the whole purpose of this project. Many software and web-sites that have really good contents failed to meet their objective to the users simply because of usability problems. Something that is hard to use will require more time and effort from the users and in educational software's case, it could deter the student's interest to learn. That is why usability aspect of software design is very important to developers.

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1.2 Problem Statement

Introductory physics courses are being taught to students all over the world. One of the activities done in this course is doing laboratory experiments. Although there are some studies that indicate the ineffectiveness of doing these experiments in producing future scientist. Nevertheless, laboratory experiments are still carried out as an integral process in physics learning.

One drawback of implementing laboratory experiments is the high cost it consumes both in providing the infrastructures and the equipments. The effectiveness and availability of laboratory are limited by the size and time. For an example, if a class with 200 students needs to do an experiment, they have to be separated into 6 different time slots with around 30 students per session. Furthermore, to cater a large number of students, more equipment has to be purchased and more human resources are needed. All these consume a lot of time and money where it can be allocated to other classes or activities. With a web-based experiment, students can do the experiments at their own time and within the comfort of their own room while saving the education provider in terms of cost. The 'Online Physics Experiment' will not only be limited to the use of one particular educational institution but it will be available to unlimited numbers of participants (depending on the load of the server at one time).

Besides the time and space constraints, inadequate equipment and safety concern are issues that arise from the implementation of the traditional method. Some equipment is expensive and the lab might only have one or none at all depending on the budget given by the management of the university. When students have to share everything in the lab some will not participate because other students in the group are already handling the equipments. This situation can thwart the particular student's desire to learn and do the experiments resulting to the lack of understanding of the basic concepts in physics. Some experiments are hazardous and various safety precautions have to be taken to avoid injuries. This adds to the hassle of implementing the traditional method.

There is also the problem of whether the experiments themselves really make the students get a better understanding behind each theory taught or became just another syllabus for them to memorize. Most educational software basically just convert the

existing paper-based teaching into digital form without any emphasize on the learning theory to support the process of learning. This approach purely focuses on the technical aspect of transferring the knowledge into a new platform. In this project however, a proven and established learning theory and methodology are followed in the development. The 'Online Physics Experiment' won't be just another set of instructions and notes put in digital form but rather a rich and effective learning tool.

Another issue that is emphasized in this project is in terms of usability of the whole system. Great contents and new technologies alone won't be enough to ensure an effective learning tool. Even if this virtual physics lab already have the right approach for the learning process, multimedia and web-based application or software will still be ineffective if it is hard to use. Understanding how users perceive the system and identifying difficulties that they encounter is vital in developing this project. That is why certain usability guidelines is followed and evaluated.

In terms of economic feasibility, a virtual version of experiments can definitely cut cost. The cost of acquiring lab equipments can be very expensive depending on the experiment. Furthermore, equipments deteriorate over time and have to be replaced. Software on the other hand last forever and can be used over and over again until the experiment itself is obsolete.

There is however a drawback of implementing a virtual lab experiment. It can never replace the experience of actually doing the real experiment. Nevertheless, laboratory experiments are used in university teaching in order to enhance student understanding of the theories taught in lectures. In terms of achieving this objective, the project will determine whether students can acquire the same or better knowledge in a simulated environment compared to doing the real experiment.

1.3 Objective and Scope of Study

1.3.1 Objective

- Provide a new platform to conduct physics experiments using multimedia and web technology.
- Provide an alternative learning tool in teaching more or less as effective as the traditional hands on approach.
- Alleviate constraints of the traditional method in physics laboratory experiments.
- Develop an interactive and user-friendly system to provide the most suitable environment for an online physics experiment.

1.3.2 Scope of Study

For this project, a single experiment is developed which is resistance and Ohm's law. The experiment is based on a simple circuit which is used to determine the resistance of a given resistor.

The targeted users for the experiment are high school students taking physics and university students taking introductory physics courses. By using a learner-centered development method, learning theory and usability studies, this experiment will be more effective as a learning tool.

1.4 Benefits of the Project

There are many benefits of an online physics experiment to the community at large. In a society that emphasize on education to support its growth and ensures a bright future, one can never deny the benefits of an ongoing innovation of educational tools. As the amount of knowledge increases day by day, so must the method of transmission. Out of the many benefits of this project, these are the significant ones:

- **Allows Distance Learning**

    One significant benefit of this project is that it allows users from anywhere in the world to do this physics experiment and learn from it, provided that the user have internet access. This is the most important achievement of the internet, the sharing of information across the world.

- **Paperless Activity**

    The traditional implementation of physics experiments uses a lot of paper, both in preparing for the lab manuals and also the lab reports afterwards. This project simply eliminates any usage of paper and therefore reduces the need to cut down trees for papers. It will be a great benefit to the environment.

- **Lower Cost**

    With an online experiment, the overall cost of conducting an experiment is much lower compared to the traditional laboratory implementation. This is because this project can be use by many educational institutions at one time. There is no need for the redundant laboratory setup in each schools, colleges and universities. The cost of buying equipments and maintenance is totally eliminated. Even the additional human resources such as lab technicians and tutors can be eliminated.

- **Safer Environment**

    Experimentation can be a very dangerous activity especially if it involves hazardous materials. Although the resistance and Ohm's law experiment only pose little hazard of electric shock, taking other experiments such as radioactivity, an online version is certainly the best safer alternative compared to dong the actual experiment hands on.
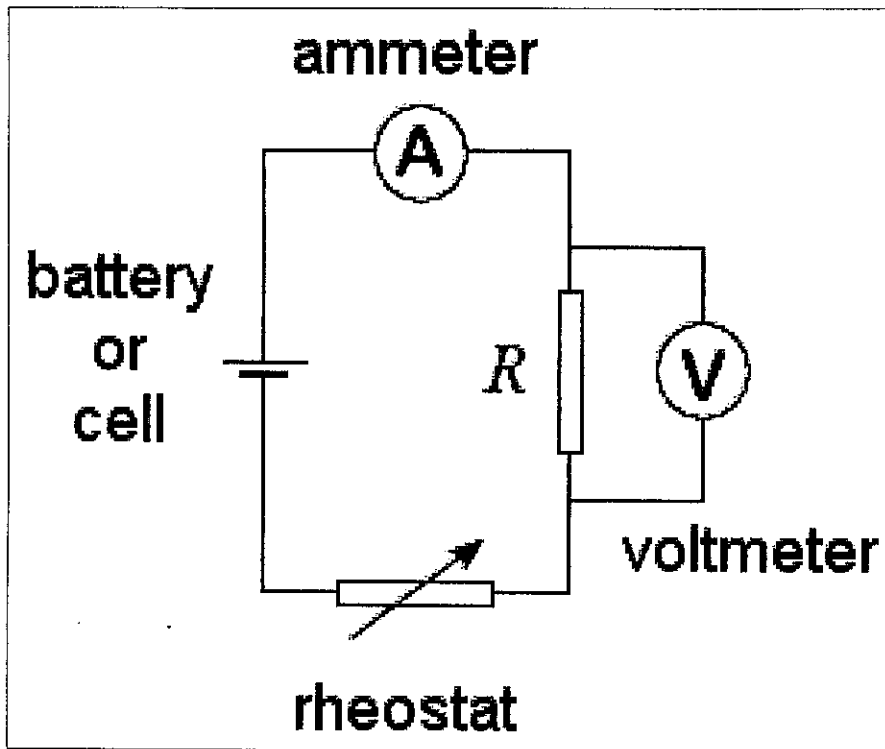
Figure 1.1: Simple Circuit Diagram

(http://www.8886.co.uk/ref/ammeter_voltmeter_circuit.htm)

The figure above shows the diagram of a simple circuit which used to find the resistance of a fixed resistor represented by "R". The online version to be developed is based on this experiment for resistance and Ohm's law topic.

The assimilation theory is incorporated into this experiment in the pre-laboratory reading materials. The reading materials gives student prior knowledge about the experiment and the theory behind it.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Physics Laboratory Work

Practical laboratory work is widely used as a teaching strategy and is also seen as crucial in developing an understanding of the procedures of scientific enquiry. Science in the laboratory was intended to provide experience in using instruments and materials to help students develop their conceptual understanding.

But several researches have provided findings that the virtue of physics laboratory experiment is untrue. This is mainly due to the fact that laboratory experiments are merely a set of instructions that the students followed blindly and hence cannot relate to the physics concept and theories being taught in class.

Most students cannot meaningfully summarize the important aspects of an experiment they have just completed. Usually they recall some of their manipulations in the laboratory, but are unable to articulate the central goal of the experiment, its underlying theory or its basic methods. Thus, despite several hours spent in working with laboratory apparatus, many students seem to learn from this experience little of lasting value. Despite various research and studies in this particular subject, the implementation of current laboratory experiments still cannot fulfill its intended objective.

In developing this project, it is important to ensure that the contents and structure of the experiments developed can bring out the desired learning outcome from students.

2.2 Virtual Education

Virtual education refers to instruction in a learning environment where teacher and student are separated by time or space or both and the teacher provides course content through course management applications, multimedia resources, the internet, and video conferencing. Students receive the content and communicate with the teacher via the same technologies. (Zucker, 2003)

There are several themes of virtual or online education that is emphasized in this project. The first one is connectivity whereby online education provides both the students and teachers the ability to connect to each other via email, forums and chat rooms. Instructors define the goals and facilitate the learning process so that the students can discover the contents on their own. The next theme in online education is unboundedness whereby it removes the boundaries of where and when students learn. Last but not least is the multisensory experience provided by the multimedia technology. Although the interactions may not be as rich or complete as firsthand experience, it can avoid and solve many other problems of the traditional method.

The promise of distance learning technologies to solve the problem of access to post secondary education is partially realized in numerous programs across the nation and spanning the globe. Web technologies can solve many but not all educational problem. Several drawbacks include the inadequacy of faculty student personal interaction and the inability for students to receive immediate feedback about their work. Macromedia Flash has been able to address these issues. It is widely used for animation in introductory electrical engineering courses. It is affordable, easy to use, portable and the player is free. (Ferre, 2002)

2.3 Virtual Physics Experiments

The concept of a virtual laboratory for physics experiment is not new in a sense that many multimedia contents are available in the internet. But most of them lack the interactive elements so the students can explore the different possibilities and outcome from various inputs.

A computer-based learning entity which consists of just text and graphics (whatever their quality and power of visualization), is not making use of the computer: in principle it can be done as well on paper (McKenna, 2004).

Simply reading on the computer presents the same problems as simply reading a textbook. Experiencing a concept or idea engages students and an engaged student is a learning student. (Callahan, 2002).

Furthermore, a detailed study is needed to determine how students perceive the virtual version of the experiments so that the best experiment can be identified and used.

2.4 Usability

Usability addresses the relationship between tools and their users. In order for a tool to be effective, it must allow intended users to accomplish their tasks in the best way possible. The same principle applies to computers, websites, and other software. In order for these systems to work, their users must be able to employ them effectively. Usability depends on a number of factors including how well the functionality fits user needs, how well the flow through the application fits user tasks, and how well the response of the application fits user expectations.

From the user's perspective usability is important because it can make the difference between performing a task accurately and completely or not, and enjoying the process or being frustrated. From the developer's perspective usability is important because it can mean the difference between the success and failure of a system. From a management point of view, software with poor usability can reduce the productivity of

the workforce to a level of performance worse than without the system. In all cases, lack of usability can cost time and effort, and can greatly determine the success or failure of a system.

Multimedia provides more design options but also requires design discipline. The arguments were that ad hoc use of multimedia confuses users and makes it harder for them to understand information. For instance, unnecessary use of animation or video clips can distract users' attention, so the users may not be able to find the important information (Nielsen, 2000).

The key principle for maximizing usability is to employ iterative design, which progressively refines the design through evaluation from the early stages of design. The evaluation steps enable the designers and developers to incorporate user and client feedback until the system reaches an acceptable level of usability.

The preferred method for ensuring usability is to test actual users on a working system. Achieving a high level of usability requires focusing design efforts on the intended end-user of the system. There are many ways to determine who the primary users are, how they work, and what tasks they must accomplish. However, clients' schedules and budgets can sometimes prevent this ideal approach. Some alternative methods include user testing on system prototypes, a usability inspection conducted by experts, and cognitive modeling.

2.5 Ten Usability Heuristics

These are ten general principles for user interface design. They are called "heuristics" because they are more in the nature of rules of thumb than specific usability guidelines. (Nielsen, 2005)

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help users recognize, diagnose, and recover from errors
- Help and documentation

2.6 First Principles of Interaction Design

The following principles are fundamental to the design and implementation of effective interfaces, whether for traditional GUI environments or the web. Of late, many web applications have reflected a lack of understanding of many of these principles of interaction design, to their great detriment. Because an application or service appears on the web, the principles do not change. If anything, applying these principles becomes even more important. Below are sixteen fundamental principles in designing a system. (Tognazzini, 2007)

I. Anticipate what user wants and need.

II. Give autonomy to user

III. Use gray scale differentiation to facilitate user with color blindness

IV. Apply consistency in structure and design

V. Always select default settings automatically

VI. Increase efficiency of user's productivity

VII. Construct explorable interface

VIII. Use Fitts' law

IX. Use standard human-interface object

X. Reduce latency

XI. Reduce learning curve

XII. Use easy-to-grasp metaphors

XIII. Protect user's work

XIV. Improve readability

XV. Track user's state

XVI. Provide visible navigation

2.7 Don't Make Me Think! Usability Principle

A good design doesn't make users stop and think about something that they are unsure about. The design must first be eliminated of any objects that may raise questions to users. For instance, make the links different from ordinary text. Links should be in a different color and underlined. Pages should also be made self evident, just one look and users already know what it is and how to use it, and in other words it should be self explanatory. (Krug, 2000)

This principle is essential to ensure that users don't waste their time and energy on bad design that raises questions and uncertainties. By following this principle, users can do what they intend to do immediately and effectively.

2.8 Assimilation Theory

The assimilation theory (Ausubel, 2000) is a theory which emphasize on cognitive learning which is the acquisition and use of knowledge.

"If I had to reduce all of educational psychology to just one principle, I would say this, the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." (Ausubel, Educational Psychology: A Cognitive View, 1968)

The key idea in the assimilation theory is "meaningful learning" where the learning process is controlled by the learner in which new information is related to an existing knowledge of the learner. In other words, it is an assimilation of new knowledge into the knowledge structure of the learner's mind. Figure 2.1 shown below is a concept map of the assimilation theory.
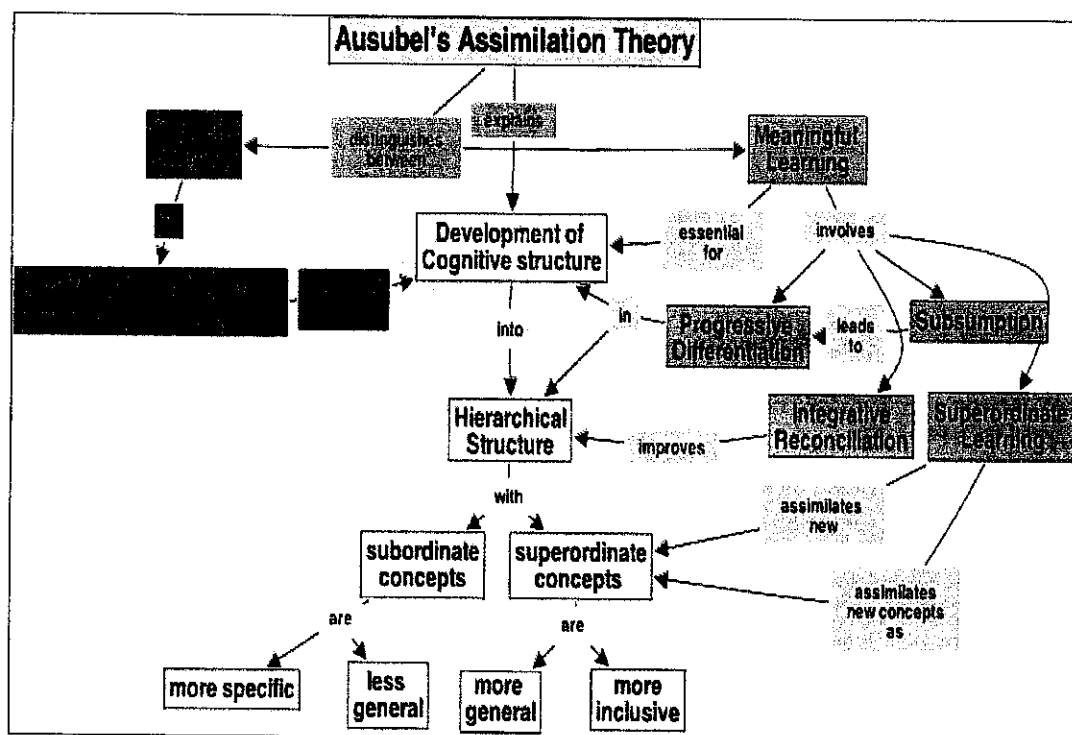
Figure 2.1: Overview of Assimilation Theory

(http://cursa.ihmc.us/servlet/)

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Meaningful learning is defined as a process that relates learning with the cognitive structure of the learner in non-arbitrary and substantial ways. A non-arbitrary way means that the relation of the new information with the cognitive structure is specific, and is carried out with previous knowledge already existing in the learner; such previous knowledge may be ideas, concepts or propositions known as "subsumptions" and operate as anchorage to new knowledge. (Valeiras, 2005)

2.9 Flash Usability

Macromedia describes its Flash product as a tool that can help with creating "engaging applications" and "low-bandwidth" animations, which you can use to "create the ultimate user experience". As with any tool, there are advantages and disadvantages. It's important to design your Web site with your user's needs in mind because no matter how your site tries to create revenue -- whether through online sales or advertising -- it can't succeed without users. And since there are millions of Web sites out there, users won't come back to ones that they find hard to use.
(Wheeler, 2006)

Some of advantages of using flash to develop this experiment are:
- Smaller file size by using vector graphics
- Flexible vector graphics
- Flash's SWF file format is fairly open standard
- Widespread acceptance and adoption of Flash Player
- Cross-platform development environment
- Allows for user interactivity
- Reusable Objects

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CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Procedure Identifications

A learner-centered approach to instruction can · be found in the tried-and-true methodology known as instructional design. Refined over six decades in military and corporate training environments, this discipline utilizes a variety of techniques that focus directly on effectively meeting learner needs. (Epsilon, 2005).

The ADDIE instructional design model provides a step-by-step process that helps courseware developers plan and create instructional programs. It is based on a learner-centered approach that emphasize on developing instructional materials based on what the user needed. The ADDIE design model revolves around the following five components:

- Analysis
- Design
- Development
- Implementation
- Evaluation
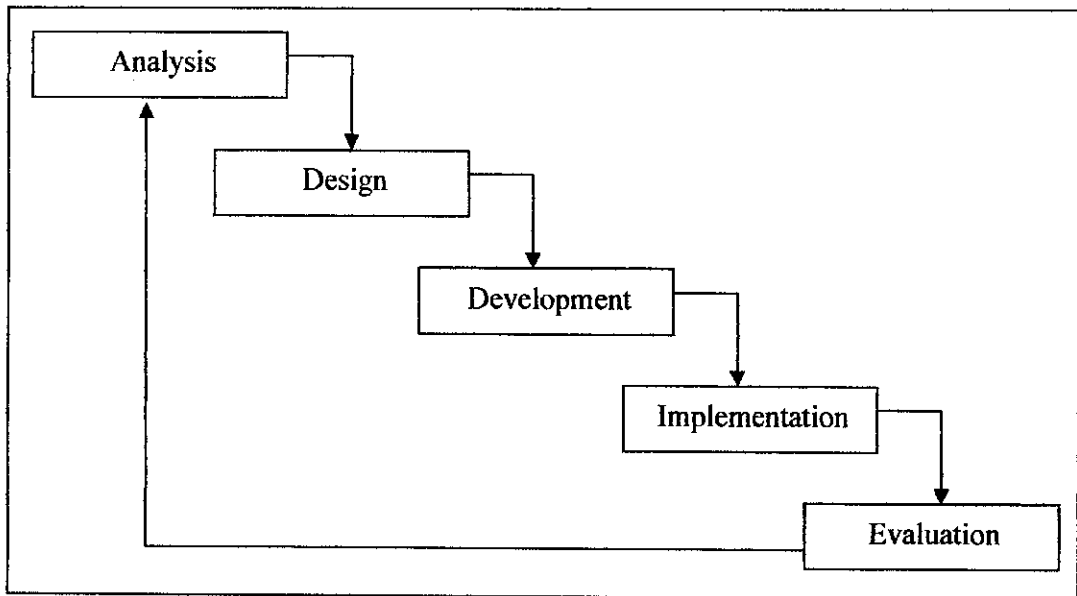
Figure 3.1: ADDIE Methodology

(http://epsilonlearning.com/focus.htm)

In the analysis phase, first of all, the targeted users are identified. This project is meant for high school and university students that are taking introductory physics course. Then the student's needs are identified as well as different learning styles and knowledge gap. This is the part where discussions with Assoc. Prof. Abu Hassan Husin help determine the contents and the process flow of the experiment.
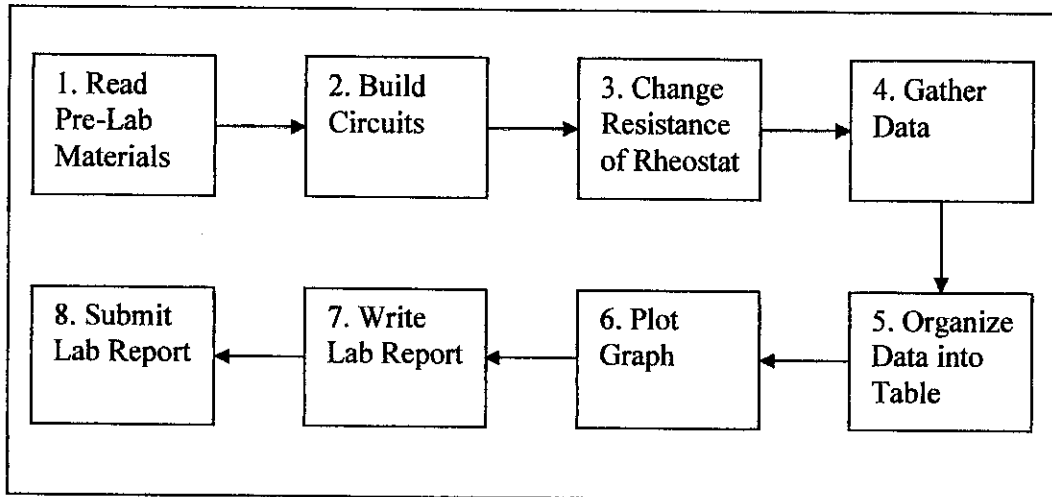
Figure 3.2: Process Flow

Then, in the design phase, the overview of the whole experiment is developed from scratch. This includes the design of the website and the flash-based experiment. The flow of the experiment is based on the process flows that have been identified in the analysis phase. The graphic design mostly involves working with Adobe Photoshop from drawing all the equipments up to the whole circuit and web design. The design phase gives an overall look of what to develop in the next phase.

In the development phase, learning materials, resources, and environment are developed and produced according to the design plan. First of all, all the graphic elements are developed. Then, algorithms are developed prior to the coding activity.
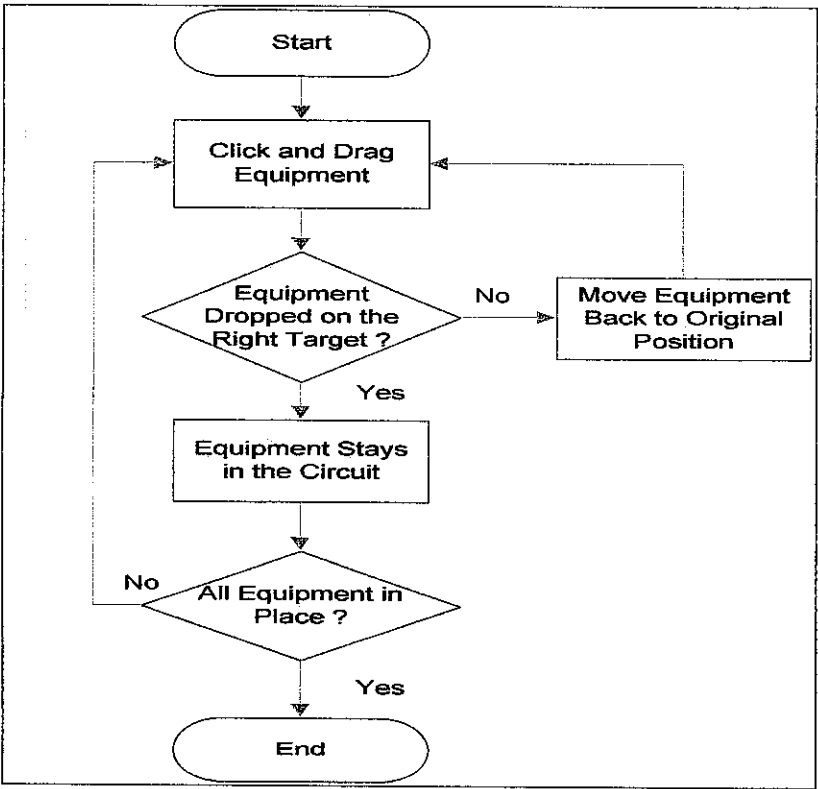
Figure 3.3: Drag and Drop Algorithm

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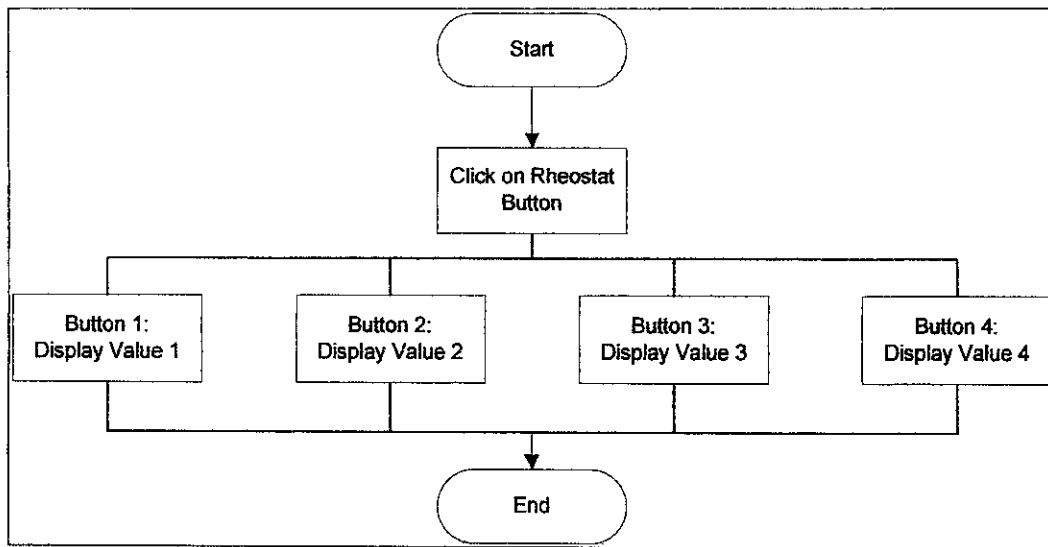
Figure 3.4: Find Resistance Algorithm

In the implementation phase, the learning program is delivered as specified. The experiment is uploaded to two free web hosting services and ready to be used. The experiment can be accessed at:

- http://safwan.hostsnake.com
- http://sterling.gigacities.net

The final phase of this project is the evaluation phase where the system will be tested with real users to determine the effectiveness of the whole learning process. Another aspect to be evaluated is the usability of the system. During the design phase, an evaluation was planned to be conducted on introductory physics students. There should be at least three groups of students, one using only the traditional laboratory work, one using the online experiment and another group using both version of the experiment. However, this evaluation is outside the scope of the author's expertise and would have to be done by an expert in physics education. As of this moment, the usability evaluation tool is still in development and will be conducted in the near future.

3.2 Development Tools

- **Adobe Flash**

  Adobe Flash is an authoring tool used to develop interactive multimedia contents. In this project, Flash MX is used in developing the interactive circuit part of the experiment while the rest of the contents are in pure HTML.

- **Adobe Photoshop**

  Adobe Photoshop is a commercial graphic editing software. In this project, Adobe Photoshop 7 is used in developing almost every graphical elements of the experiment.

- **Notepad++**

  Notepad++ is an open source code editor. Most of the coding for this project is done using this code editor. Color cues for syntax are provided for several different programming and scripting language including actionscript, HTML, and CSS.

CHAPTER 4

RESULTS / DISCUSSIONS

4.1 Results and Discussions

This section includes the preliminary design of the systems' interface and layout together with the discussions on why it is so. The home page design for the site is shown below in Figure 4.1.

INTRODUCTORY PHYSICS LAB

ANNOUNCEMENT

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

TOPICS / EXPERIMENTS

1. Measurement
2. Ballistic Pendulum
3. Acceleration due to Gravity
4. Power and Energy
5. Electrical Circuits

Figure 4.1: Home Page

The home page serves the purpose of telling users what the whole site is all about. From the title itself "Introductory Physics Lab" people can tell what the site contains, an online introductory physics experiments. Next, we have an announcement section where the webmaster can put any important notice. The target users of this site are of course students which will come to do the experiments. So lecturers can put announcement on what his or her students are supposed to do or maybe inform them of any newly added experiments. Even without lecturer's instructions students can explore the whole site for themselves.

Right below the announcement section is the list of topics and experiments available in the site. Each link is in blue the standard color used widely in order to differentiate from the normal text color which is in black. The contents' boxes are colored in white while the background color of the page is in light blue in order to increase readability. White color makes it easy for users to focus on the center of the page where the contents are located.

The next section is the experiment page where a flash interactive experiment is put in the middle. Also note that there is a breadcrumb just below the header that tells people where they are and also acts as the navigation. The whole structure of the site is quite flat with only two main tiers, the home page and the experiments. The rest are within the flash component itself. The experiment page is shown in figure 4.2.

Home > Experiment X
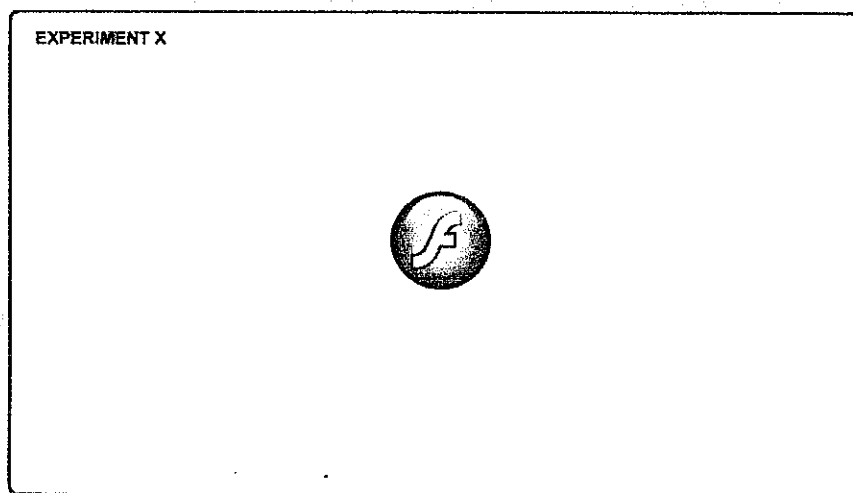
EXPERIMENT X

Figure 4.2: Experiment Page

Figure 4.3 below shows the layout and design of the flash experiment. It is the first page of the experiment that contains the introduction for the experiment including the theory behind it.
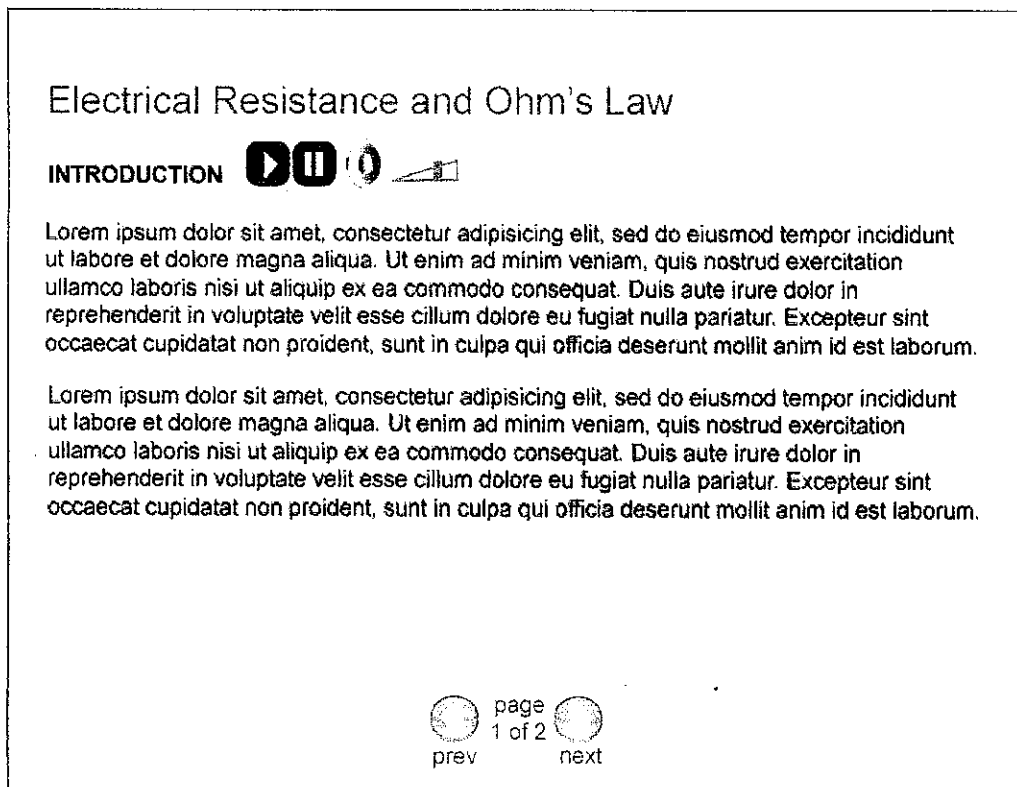
Figure 4.3: Experiment's Introduction

Users will have the option to hear the whole text if they prefer learning by listening. By using both sound and text, the online learning experience can be useful to both visual and auditory learners.

The introduction's purpose is to expose users to the theory and real life situation that they may encounter or have knowledge about. This is where the assimilation theory comes in where students can relate their existing knowledge with the new knowledge that they will discover while doing the experiment.

The last page of the flash experiment is the experiment itself where students can their ability and see whether they can do the experiment based on their existing knowledge. Instead of following instructions blindly, students carry out the experiment based on what they learned prior to the experiment. The sample given in figure 4.4 below is based on the electrical circuit experiment. In this experiment, students are asked to drag the apparatus given at the sides and assemble it in the middle to construct a simple electrical circuit.
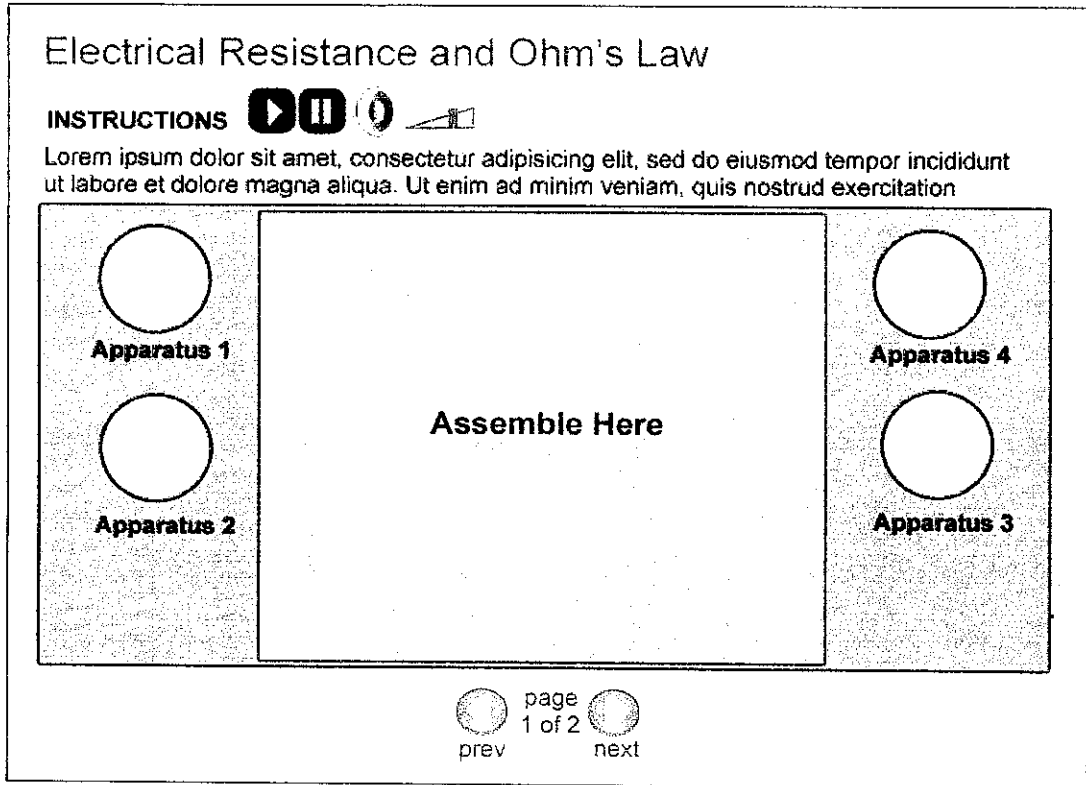
Figure 4.4: The Flash Experiment Design

In the development stage, the design that is planned earlier is changed due to coding complexity. A simpler but easier to build design is used and some of the functionalities planned are also not included. In order to meet the deadlines, only core functions are developed. Other functions such as sounds can be included later provided there is enough time. Below are screenshots of the project's progress as of 27th March, 2008.

Home > Electricity > Electrical Resistance & Ohm's Law

Electrical Resistance & Ohm's Law

Objective: To find the resistance of a given resistor

Apparatus: Power Supply, Ammeter, Voltmeter, Rheostat, Resistors, Switch, Connecting Wires

Learning Outcomes: After doing the activity the students should be able to

1 state the meaning of a battery, resistor, resistance, current, Ohms law and an ideal circuit
2 connect the circuit and measure the current passing through and voltage across a given resistor
3 determine the resistance of a given resistor and its uncertainty
4 apply $V = IR$ to solve related problems

Introduction

Battery

A battery is a device that uses chemical energy to separate positive and negative charge, producing potential difference between its terminals. The potential difference causes the current to flow in the wire (Walker 2004).

A battery uses chemical reactions to produce a difference in electric potential between its two ends, or terminals.

In batteries, a charge separation is maintained between two points, thus creating electric fields that can then do work. It is clear that

Figure 4.5: Reading Materials

The developed website shown above in figure 4.5 are simpler and are much smaller in size compared to the one proposed during the design phase. This can be an added benefit to project as it will help users with slow connection to access the website faster.

The figure above shows the first activity that users have to do in conducting this experiment which is the reading part. The reading materials provide the initial knowledge for users in understanding the concept and theory of the experiment. The introduction includes information about battery, resistor, resistance, current, Ohm's law and a table describing different effects of electric currents on the body according to the amount exposed to.
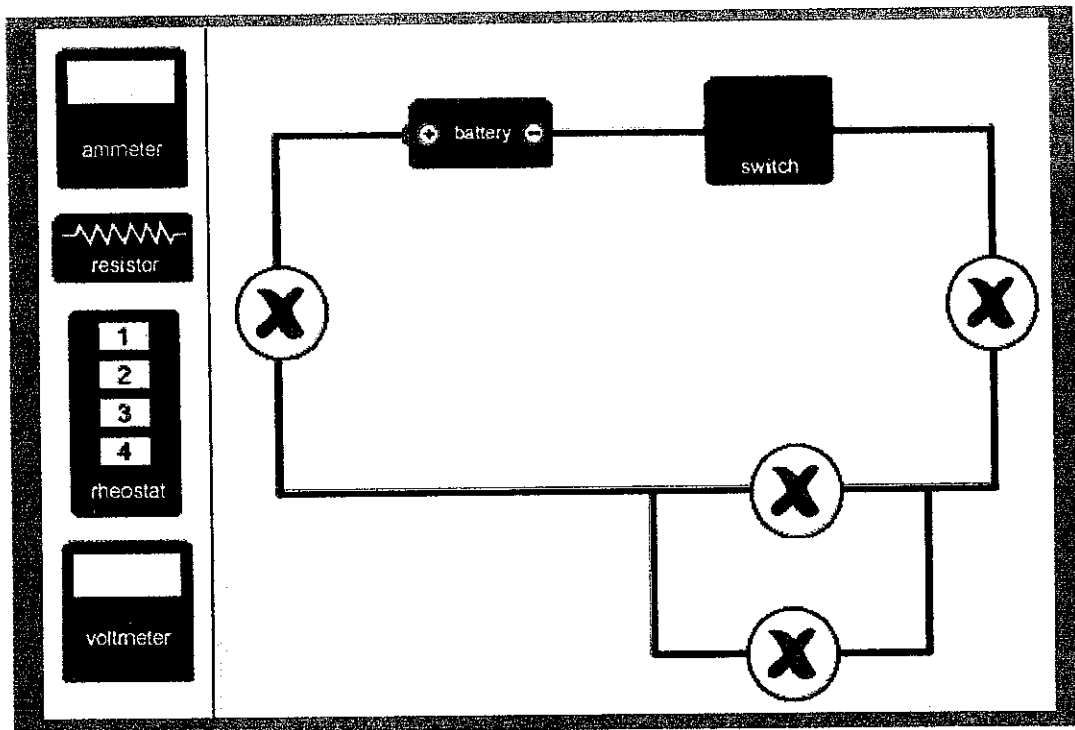
Figure 4.6: Drag and Drop Operations

The experiment that has been developed as in figure 4.6 requires users to drag the equipments on the right and drop it on the targets provided in the circuit. If the user drop the equipment on the wrong place, it will automatically move back to its' original place. There is no limit as to how many times users can try and drop on the wrong targets, but only when all four equipments are in their correct places users can proceed to the next activity by pressing on the next activity by pressing on the switch.

In this circuit, both the ammeter and the rheostat can be placed on either the rightmost target or the leftmost target. The circuit will still run correctly no matter which side the ammeter or the rheostat is placed. The resistor should be placed on the middle target while the voltmeter on the bottommost target in order to evaluate the resistance of he resistor. The switch can be turned on and off at anytime, but until all equipments are placed correctly, no message indicating the success will appear. This is done by using decremental and incremental counter that evaluates when the equipments are placed on the targets.
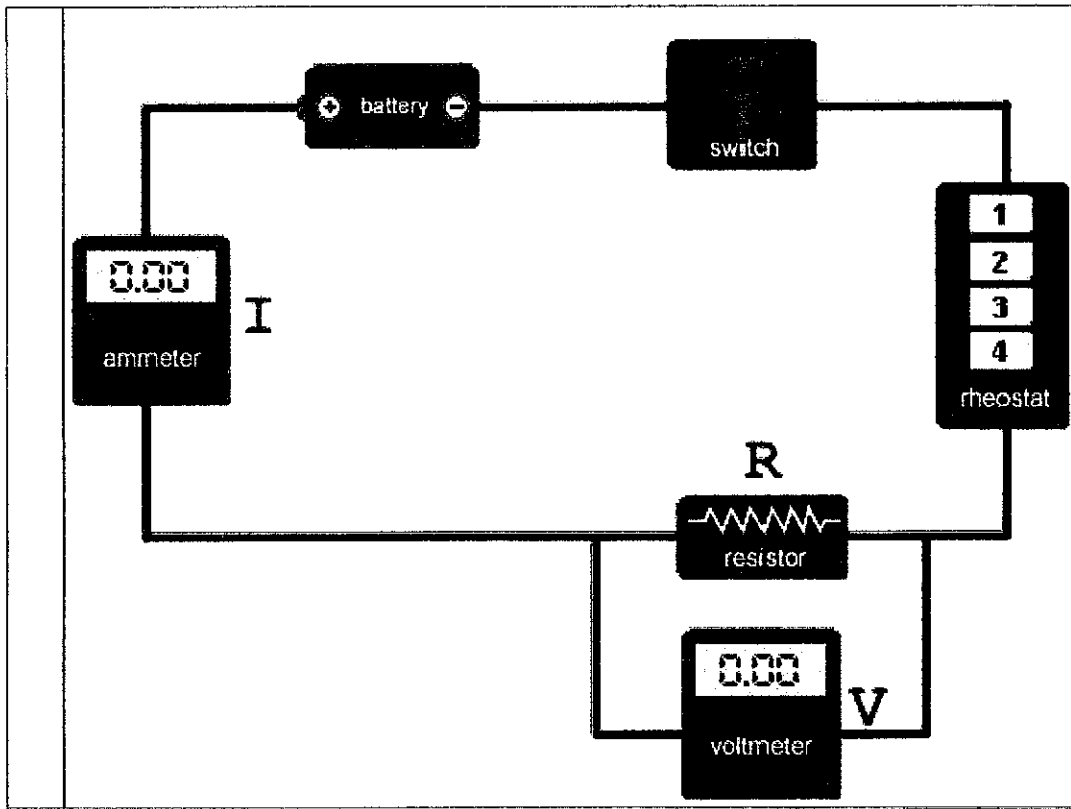
Figure 4.7: Calculate Resistance

The second activity of the experiment is to calculate the resistance of the resistor from the voltage and current given. Users will only have to click on the buttons on the rheostat to change its resistance. This will then change the value of the current in the circuit. Users can get the data from both voltmeter and ammeter.

After the users have finished the second activity, the data will be organized in an appropriate table. Then, users will plot a graph with the gathered data and see the relationships between the variables. Last of all is the writing of the lab report. Users are given a guideline on what to put in the report and how to write it. Unfortunately, for the time being users will have to do these activities in separate software. The data table and graph can be plotted in a spreadsheet program such as the proprietary Microsoft Excel or OpenOffice Calc if users opt for open source software. Meanwhile, to write the lab report users can use word processor program such as the proprietary Microsoft Word or OpenOffice Writer if users opt for open source software. After all the lab report is

done, users can print it out and hand it to the lecturer or simply email it to make the whole learning process paperless.

4.2 Functional Testing

At the end of both the development and implementation phase, functional testing of the system is carried out. Functional testing involves the testing of each component and task involved in the system. Table 4.1 and Table 4.2 show the test result for the two activities in the experiment:

Table 4.1: Test Result for the Drag and Drop Module

Component / Task	Expected Test Result	Test Result
Ammeter	■ Can be dragged and dropped on its actual target.	■ Successful
Voltmeter	■ Can be dragged and dropped on its actual target.	■ Successful
Rheostat	■ Can be dragged and dropped on its actual target.	■ Successful
Resistor	■ Can be dragged and dropped on its actual target.	■ Successful
On / Off Switch	■ Changes state when clicked. ■ Successful message and next button will appear only when all components are in place.	■ Successful
Next button	■ Appear only after all the conditions are met and the on / off switch is clicked. ■ Change page to next activity	■ Successful
Success Message	■ Appear only after all the conditions are met and the on / off switch is clicked.	■ Successful

Table 4.2: Test Result for the Find Resistance Module

Component / Task	Expected Test Result	Test Result
Ammeter	▪ Changes value after different button on the rheostat is pressed.	▪ Successful
Voltmeter	▪ Changes value after different button on the rheostat is pressed.	▪ Successful
Rheostat	▪ Pressed button will change color to green.	▪ Successful

The test results on both modules shows that every component works correctly and every task is able to be executed successfully.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The development of this project intends to provide an alternative to the current implementation of traditional laboratory experiments and has been successful in doing so. The Online Physics Experiment is another step towards changing the way of when, how and where people learn while maintaining the knowledge that they gain from learning process. The only constant thing in life is change. Online learning is the future of education until another life-changing breakthrough is discovered. There have been other attempts to deliver such experiments via the web especially by physics education researchers. But, further developments and studies are needed to enhance and innovate continuously in maximizing the effectiveness of online learning. To sum it all, this project is a small step towards providing users a more comprehensive and effective online learning environment.

5.2 Recommendations

As of the moment this report is written, no testing or evaluation has been done to measure the effectiveness of this experiment. The success factor of this project is solely based on the tested and proven methods involved in developing this experiment. The assimilation theory has been incorporated into many learning tools before this and the ADDIE instructional design is largely accepted as an effective approach in developing

instructional materials. In order to measure the success of this project, a form of evaluation tool need to be developed.

In terms of the activities in this experiment, the task of data gathering and plotting the graph can be added as a web based element instead of using separate software. Spreadsheet software used to organize the data and plot graph can be replaced by a web-based tools. The lab reports can also be done online by storing it in an online database. However, better incorporation of the assimilation theory into this experiment is believed to be achievable by adding another activity which gives an example of the real world application of the simple circuit. This way user can relate more on this experiment with their existing knowledge of the real world.

Another shortcoming of this project is the unrealistic features of the equipments used in the experiment. For students that's using only the online experiment, they will not know how the actual equipment really looks like. This problem can be solved by creating a 3-D model of the equipments to add more realism. Real pictures of the equipments can also be added in the introduction section.

Since this project only involves a simple experiment, there is very limited interactivity and features provided. For a more complex and interactive experiments to be developed, a more collaborative approach has to be taken. Experts in both the physics and programming part need to spend more time and effort together in the development of more experiments.

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APPENDICES

APPENDIX A: PROJECT GANTT CHART (SEMESTER 1)

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SW
1	Selection of Project Topic															
	✓ Topic Approval	█	█													
2	Preliminary Research Work			█	█	█	█	█	█	█						
	✓ Background Study															
	✓ Problem Statement															
	✓ Scope of Study															
3	Submission of Preliminary Report															
4	Literature Review			█	█	█	█	█	█	█	█	█				
	✓ Physics Laboratory Work															
	✓ Virtual Education															
	✓ Virtual Physics Experiments															
	✓ Usability															
	✓ Ten Usability Heuristics															
	✓ First Principle of Interaction Design															
	✓ Don't Make Me Think Usability Principle															
	✓ Assimilation Theory															
5	Design Process															
	■ Initial Uncoded Design												█	█		
6	Submission of Progress Report															
7	Submission of Interim Report															
8	Oral Presentation															

APPENDIX A: PROJECT GANTT CHART (SEMESTER 2)

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SW
1	Analysis	■	■													
	✓ Experiment's Requirements															
	✓ Process Flow															
2	Design			■	■	■										
	✓ Experiment's Structure															
	✓ Circuit Layout															
	✓ Web Layout															
3	Submission of Progress Report 1															
4	Development			■	■	■	■	■	■	■	■	■				
	✓ Graphical Elements															
	✓ Algorithms															
	✓ Coding															
	✓ Testing															
5	Submission of Progress Report 2															
6	Seminar															
7	Implementation												■			
	✓ Upload to Web Server															
	✓ Testing															
6	Pre-EDX															
7	Submission of Final Draft															
8	Oral Presentation															

APPENDIX B: ACTIONSCRIPT CODING

```
//Actionsript for Experiment Resistance(a) < fyp.as >
stop();

nextbtn._visible = false;
donetext._visible = false;
//smooth movements
onMouseMove = function(){
updateAfterEvent();
}
//counter for correct placement
EquipCounter = 0;
//ammeter scripts
ammeter.onPress = function(){
//(target,lock,left,top,right,bottom)
startDrag(this,true,570,370,30,30)
}
ammeter.onRelease = function(){
this.stopDrag();
checkTarget4(this);
}

//resistor scripts
resistor.onPress = function(){
startDrag(this,true,570,370,30,30)
}
resistor.onRelease = function(){
this.stopDrag();
checkTarget2(this);
}

//rheostat scripts
rheostat.onPress = function(){
startDrag(this,true,570,370,30,30)
}
rheostat.onRelease = function(){
this.stopDrag();
checkTarget1(this);
```

APPENDIX B: ACTIONSCRIPT CODING

```
//voltmeter scripts
voltmeter.onPress = function(){
startDrag(this,true,570,370,30,30)
}
voltmeter.onRelease = function(){
this.stopDrag();
checkTarget3(this);
}

//swap on/off switch
switchOff.onPress = function(){
        this._visible = false;
        switchOn._visible = true;
                if (equipCounter >= 4) {
                        donetext._visible = true;
                        nextbtn._visible = true;
                }
                else {
                        donetext._visible = false;
                }
}
switchOn.onPress = function(){
        this._visible = false;
        switchOff._visible = true;
        donetext._visible = false;
}

function checkTarget1 (drag){
        if (drag.hitTest(target1)) {
                target1._visible = false;
                EquipCounter ++;
        }
        else if (drag.hitTest(target4)) {
                target4._visible = false;
                EquipCounter ++;
        }
        else {
                target1._visible = true;
                target4._visible = true;
                setProperty(rheostat, _x, "47");
                setProperty(rheostat, _y, "235");
        }
}
```

APPENDIX B: ACTIONSCRIPT CODING

```
function checkTarget2 (drag){
        if (drag.hitTest(target2)) {
                target2._visible = false;
                EquipCounter ++;
        }
        else {
                target2._visible = true;
                setProperty(resistor, _x, "47");
                setProperty(resistor, _y, "130");
        }
}

function checkTarget3 (drag){
        if (drag.hitTest(target3)) {
                target3._visible = false;
                EquipCounter ++;
        }
        else {
                target3._visible = true;
                setProperty(voltmeter, _x, "47");
                setProperty(voltmeter, _y, "360");
        }
}

function checkTarget4 (drag){
        if (drag.hitTest(target4)) {
                target4._visible = false;
                EquipCounter ++;
        }
        else if (drag.hitTest(target1)) {
                target1._visible = false;
                EquipCounter ++;
        }
        else {
                setProperty(ammeter, _x, "47");
                setProperty(ammeter, _y, "44");
                target4._visible = true;
                target1._visible = true;
        }
}
```

APPENDIX B: ACTIONSCRIPT CODING

```
stop();
//initial values for voltmeter & ammeter
Ampere = "0.00";
Volt = "0.00";
//when user press button 1 on rheostat
init1.onPress = function() {
        this._visible = false;
        press1._visible = true;
        init2._visible = true;
        init3._visible = true;
        init4._visible = true;
        Ampere = "2.00";
        Volt = "4.00";
}
init2.onPress = function() {
        this._visible = false;
        press2._visible = true;
        init1._visible = true;
        init3._visible = true;
        init4._visible = true;
        Ampere = "4.00";
        Volt = "8.00";
}
init3.onPress = function() {
        this._visible = false;
        press3._visible = true;
        init1._visible = true;
        init2._visible = true;
        init4._visible = true;
        Ampere = "6.00";
        Volt = "12.00";
}
init4.onPress = function() {
        this._visible = false;
        press4._visible = true;
        init1._visible = true;
        init2._visible = true;
        init3._visible = true;
        Ampere = "8.00";
        Volt = "16.00";
}
```