Physics Virtual Learning

By

Noruzanna Abdul Nasir

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Information Technology)

JUNE 2006

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CERTIFICATION OF APPROVAL

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Approved By,

....
(Dr. Wan Fatimah Wan Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
June, 2006

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.

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(Noruzanna Abdul Nasir)

ABSTRACT

Discovery Learning aims to obtain and construct knowledge about a domain by performing experiments and inferring rules and properties of the domain from the results of those experiments. It is based on the secondary students' needs within limits as well as carefully prepared environment which required students to act in the same manner as scientist when discovering the properties and relations of the domain that is simulated. The objectives of this project is to develop Virtual Physics Lab supported with discovery learning method in a way that providing students with exploratory learning environment. Besides, it will determine the effectiveness of scientific discovery learning approach adapted in computer simulation compared to other learning theories. It is also an effective solution for cost and time while highly support distance education as the technology grows. The development of Virtual Physics Lab supported by discovery leaning would improve the effectiveness of the simulation-based learning outcomes. Through Software Development Life Cycle and prototype approach, it will be developed using Easy Java Simulation which is tools designed for creation of computer simulation. Based on findings and observation, it is believed that learning support in a simulation environment should be directed to invite meaningful, systematic and reflective discovery learning.

ACKNOWLEDGEMENT

In the name of God, the Compassionate, the Merciful, the Author would like to thank him for giving the strength, skill, knowledge, patience and good health in producing this project. The greatest pleasure in writing such report is when it comes to acknowledge the efforts of many people whose names may not appear on the cover but without their hard work, cooperation, support and understanding, producing this report would be impossible.

First of all, thank you to the most supportive supervisor, Dr. Wan Fatimah Wan Ahmad and other lecturers who had contributed to the success of research topic and developing this system. Specially dedicated to my family, thank you for all the encouragement and inspiration given. The Author also would like to thank all his colleagues who have together strive through the semesters completing the final year project.

Lastly, warmth gratitude to all participants of the survey and thank you for the ideas and comments. Thank you for all of your cooperation and may God bless you.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

The Physics Virtual Learning is a computer simulation which is designed to permit the creation of a laboratory-based physics course to be used either as a stand alone distance learning course or as an enhancement to currently existing conventional lecture course. It presents as the lab component of Physics course, tutorials for remedial work in conventional courses, extra credit or missed lab work and for interactive and open-ended student investigations.

Discovery Learning is a learning method that encourages students to ask questions and formulate their own tentative answers, and to deduce general principles from practical examples or experiences. It is a learning situation in which the principal content of what is to be learned is not given but must be independently discovered by the student, making sure the student an active participant in his learning. In the past decade, the research on discovery learning has evolved from concept discovery learning towards more sophisticated and authentic scientific discovery learning characterized by the need to design scientific experiments.

Since computer simulation has the capacity to provide students with an exploratory learning environment, it has been regarded as a powerful tool for scientific discovery learning. Through this approaches, students need to generate hypotheses, design experiments, predict their outcome, interpret data and reconsider hypotheses (van Joolingen, 2000) in order to construct knowledge about the domain. With each of these learning processes, problems can arise where students can be failed to state testable hypotheses, design uninformative experiments or interpret experimental results badly.

Virtual lab is one of the most interesting e-learning solutions for higher education. It aims to fulfill the same function as traditional laboratories; to give students the opportunity to put into practice their recent acquired knowledge and skills through unlimited and repeated use. The use of virtual lab in higher education allows the progressive disappearance of the limitations of space and time. Through virtual lab, student use a simulator that reproduces a real situation and provide real experience.

Physics Virtual Learning is designed to support an approach wherein students are actively engaged in their learning. This approach goes beyond current interactive simulations where students may manipulate variables but independent decision-making is constrained. The central idea of Physics Virtual Learning is the implementation of a virtual lab environment that offers students all the attendant manipulative features, ability to make mistakes and measurement errors where the conditions are very similar to those realized in real labs.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

There are growing number of studies have focused on Scientific Discovery Learning (SDL) through computer simulation within a constructivist paradigm. However, a lot of research comparing the effects of simulation-based learning to more traditional modes of learning finds simulation-based learning that involves students in active inquiry does not improve learning outcomes more consistently (van Joolingen, 2000). One explanation lies in the wide range of difficulties students may have in dealing with discovery learning processes which may encounter in four categories:

- Difficulties in generating and adapting hypotheses;
- Poorly designed experiments;
- Difficulties in data interpretations, and
- Problems regarding the regulation of discovery learning

The simulation-based learning environment cannot guarantee effective learning without sufficient support for discovery learning activities. Besides that, the idea of developing this Physics Virtual Learning emerged due to some limitations on the real laboratories implementation where faculty wished to implement a researched-based pedagogy in the classroom faces two major obstacles. The cost of equipping a lab with all the apparatus necessary to teach a single introductory physics course of this nature can exceed several thousand dollars per student workstation, without taking into account either the cost of dedicating precious building space to exclusive laboratory use or the problem of different students at different levels using the same station.

Students were assigned to a lab session which conducted for a few hours once a week. Due to time constraint and limited number of workstations, they only have a chance to obtain the experience on the lab experiment conducted and less time to really understand the theories applied. In addition, they are less exposed to the experiments conducted especially when they are working in a big group where each person has a small role in completing the task.

Currently, distance education courses in Malaysia are only for the non-scientific field. Distance education consumers were limited to the staple of mail, fax and phone communication. While normal Web-based implementation may well be fine for courses which have little need for practical training, it is quite insufficient for science and engineering based courses, for which laboratory experimentation is indispensable.

1.2.2 Significant of the Project

- **Effective simulation-based learning environment supported by discovery learning.**

  Extensive physics education research has demonstrated that student best learn scientific concepts when they have the opportunity to arrive at conclusions through exploration, experimentation and feedback in a laboratory setting, rather than through lectures and textbook exercises (Meisner, 2003)

- **Cost-effective**

  The Physics Virtual Learning initially seemed to be the best solution for cost-effectiveness when taking into account economies of scale. Besides, faculty time spent effectively communicating with students in a reasonably Web course quickly exceeds the time, effort and energy required for a traditional course. Cost-effectiveness therefore depends on reducing faculty time investment too.

- **Time-effective**

  With the implementation of Physics Virtual Learning, students can perform experiments at any location since the labs are available online for 24 hours a day. Students can now do experiments by simulation, providing a handy substitute to training in actual conditions providing them with better understanding.

- **Support Distance Education for Science and Engineering**

  Several interactive virtual labs are currently available on the Web. Some enchantments can be done to the presentation features in order to add more realism and give users the feel of presence. Allow distance students to explore and put into practice theoretical concepts disseminated in the lectures.

1.3 OBJECTIVES

The objectives of this virtual lab are:

1. To develop Physics Virtual Learning (computer simulation) supported with discovery learning that provide solution for real lab experience.
2. To investigate and observe the effectiveness of scientific discovery learning in virtual lab compared to other methods.
3. To apply constructivism learning theory in scientific experiments.
4. To support the emergence of distance education especially for science and engineering courses.

1.4 SCOPE OF STUDY

The scope of this project is focusing on phenomenon of spring, the physics principle related to the phenomenon, principle equations and variables, experimental procedures and observations. In the simulations, students can manipulate variables and perceive the consequences of their manipulations in dynamic outputs. The experimental features included four specific treatments in order to help students conduct systematic and valid experiments. In the introductory phase of the simulation, the program gave students the general explanations about scientific experimental design particularly about varying one thing at a time. Students were required to predict which of the two specified objects before running the experiments, and to check or compare their prediction against the outcome after the experiments. Finally, the conclusion of their new discovery against an experiment structure represented either by comparison table or interactive graft.

1.4.1 Feasibility of the Project within the Scope and Time Frame

There are many theories related to Physics course, the author has to narrow down the scope as time allocated for this project is not enough to cater the development of all experiments.

CHAPTER 2
LITERATURE REVIEW

2.1 WHAT IS LEARNING THEORIES?

Learning theories is an organized set of principles explaining how individual learns and how they acquire new abilities or knowledge. The importance of learning theories to provide instructional designers with verified instructional strategies and techniques for facilitating learning as well as a foundation for intelligent strategy selection (Mergel, !998)

2.2 TYPES OF LEARNING THEORIES

2.2.1 Behaviorism

The theory of behaviorism concentrates on the study of overt behaviors that can be observed and measured. It views the mind as a 'black box' in the sense that response to stimulus can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. Behaviorism is a theory of animal and human learning that only focuses on objectively observable behaviors and discounts mental activities.

This theory is relatively simple to understand because it relies on observable behavior and describes several universal laws of behavior. Its positive and negative reinforcement techniques can be very effective both in animals and in treatments for human disorders such as autism and antisocial behavior. Behaviorism is often used by teachers who reward or punish students' behaviors.

2.2.2 Cognitivism

As early as the 1920's people has begun to find limitations in the behaviorist approach to understanding learning. Behaviorists were unable to explain certain social behaviors. Cognitive theorists recognize that much learning involves associations established through continuity and repetition. They also acknowledge the importance of reinforcement, although they stress its role in providing feedback about the correctness of responses over its role as a motivator. However, even while accepting such behavioristic concepts, cognitive theorists view learning as involving the acquisition or reorganization of the cognitive structures through which humans process and store information.

2.2.3 Constructivism

Constructivists believe that students construct their own reality or at least interpret it based on their perceptions of experiences, so an individual knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events. Constructivism is a philosophy of learning founded on the premise that by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own rules and mental models which are used to make sense of our experiences. Learning therefore, is simply the process of adjusting our mental models to accommodate new experiences.

2.3 INTRODUCTION TO DISCOVERY LEARNING

2.3.1 What is Discovery Learning Method?

Discovery learning encompasses an instructional model and strategies that focus on active, hands-on learning opportunities for students. Castronova (2003) described the three main attributes of discovery learning as the following:

- Exploring and problem solving to create, integrate, and generalize knowledge
- Student driven, interest-based activities in which the student determines the sequence and frequency
- Activities to encourage integration of new knowledge into the learner's existing knowledge base

The first attribute of discovery learning is a very important. Through exploring and problem solving, students take on an active role to create, integrate, and generalize knowledge. Instead of engaging in passively accepting information through lecture or drill and practice, students establish broader applications for skills through activities that encourage risk-taking, problem solving, and an examination of unique experiences (Castronova, 2003). In this attribute, students rather than the teacher drive the learning. Expression of this attribute of discovery learning essentially changes the roles of students and teachers and is a radical change difficult for many teachers to accept.

A second attribute of discovery learning is that it encourages students to learn at their own pace (Castronova, 2003). Through discovery learning, some degree of flexibility in sequencing and frequency with learning activities can be achieved. Learning is not a static progression of lessons and activities. This attribute contributes greatly to student motivation and ownership of their learning.

A third major attribute of discovery learning is that it is based on the principle of using existing knowledge as a basis to build new knowledge (Castronova, 2003). Scenarios with which the students are familiar allow the students to build on their existing knowledge by extending what they already know to invent new ideas. A good example of this attribute would be discussion of a kindergarten student's encounter with the LOGO computer programming language. She played with the program's speed setting and discovering the true meaning of zero. The student discovered that objects that were "standing still" were still "moving" just at a speed of zero. Through the student's playing with something with which she was familiar, she was able to create a new understanding of the concept of number including zero.

2.3.2 Differences between Discovery Learning Method and Traditional Method

The most fundamental differences between discovery learning and traditional forms of learning are as the following (Castronova, 2003):

- **Learning is active rather than passive**
  Students are active in discovery learning. Learning is not defined as simply absorbing what is being said or read, but actively seeking new knowledge. Students are engaged in hands-on activities that are real problems needing solutions. The students have a purpose for finding answers and learning more.

- **Learning is process-oriented rather than content-oriented**
  The focus shifts from the end product, learning content, to the process, how the content is learned. The focus in discovery learning is learning how to analyze and interpret information to understand what is being learned rather than just giving the correct answer from rote memorization. Process-oriented learning can be applied to many different topics instead of producing one correct answer to match one question that is typically found in content-oriented learning. Discovery learning pushes students to a deeper level of understanding. The emphasis is placed on a mastery and application of overarching skills.

- **Failure is important**

  Failure in discovery learning is seen as a positive circumstance. Discovery learning emphasizes the popular lesson learned from Thomas Edison. Thomas Edison is said to have tried 1,200 designs for light bulbs before finding one that worked. Learning occurs even through failure. Discovery learning does not stress getting the right answer. Cognitive psychologists have shown that failure is central to learning. The focus is learning and just as much learning can be done through failure as success. In fact, the student probably has not learned something new if he or she never fails in the learning process.

- **Feedback is necessary**

  An essential part of discovery learning is the opportunity for feedback in the learning process. Student learning is enhanced, deepened, and made more permanent by discussion of the topic with other learners. Without the opportunity for feedback, learning is left incomplete. Instead of students learning in isolation, as is typical in the traditional classroom where silence is expected, students are encouraged to discuss their ideas to deepen their understanding.

- **Understanding is deeper**

  Incorporating all of these differences, discovery learning provides for deeper learning opportunities. Learners internalize concepts when they go through a natural progression to understand them. Discovery learning is a natural part of human beings. People are born with curiosities and needs that drive them to learn. Discovery learning allows for deeper understanding by encouraging natural investigation through active, process-oriented methods of teaching.

2.3.3 Technology's Impacts on Discovery Learning

There are five main architectures for categorizing the architectures for discovery learning (Castronova, 2003). They are case-based learning, incidental learning, learning by exploring/conversing, learning by reflection, and simulation-based learning. By utilizing these architectures, teachers can build activities to allow their students to discover the desired concepts.

Table 2.1 Summary of Discovery Learning Architecture

Architecture	Description	Example
Case-based Learning	▪ Very old ▪ Students examine cases and discuss How to solve problems.	Groups of students are given a case to read and examine. The class then discusses possible solutions to the problem described.
Incidental Learning	▪ Game-like activities ▪ Motivational	Jeopardy game Crossword puzzle
Learning by Exploring/Conversing	▪ Students asking questions ▪ Encourages thinking of multiple ways to categorize	What's in the bag? game
Learning by Reflection	▪ Learning to ask better questions ▪ Builds analysis skills	Teacher answers a student's questions with additional questions for the student to answer
Simulation-based Learning	▪ Experimenting in an artificial environment ▪ Allows for trials without fear of failing	Planning and taking a space mission

In a relatively short period of time, technology has impacted every aspect of society; however, schools have been slower to embrace technology and change to adapt to the new technological environment. Technology, however, makes discovery learning easier. Computers and the Internet give children greater autonomy to explore larger digital worlds. No longer must schools be closed communities with little contact with the outside world. More opportunities exist than ever before for students to learn through discovery.

The issues that made discovery learning difficult in the past, such as accessing current information and increasing student experiences, have been overcome by technology and are becoming ever easier as new technologies arise. Students are capable of building a learning community with a much greater collective experience base from which to draw by using technologies such as e-mail. The tools improved by the Internet make discovery learning much easier than it was in the not too distant past. Technology makes the use of discovery learning architecture types easier (See Table 2.2).

Table 2.2 Technology used with Discovery Learning Architectures

Architecture	Technology's Impact on Using Architecture
Case-based Learning	▪ More cases available to be used in class ▪ Cases can be used in an electronic form so that the cost of resources (i.e. printing, paper, etc.) is reduced. ▪ Students have access to more information to find solutions to the cases through the Internet
Incidental Learning	▪ Online tools, such as Puzzlemaker.com (2001), make the creation of puzzles and games easier ▪ Information on topics is easier to find through the Internet to build games and puzzles
Learning by Exploring/Conversing	▪ A larger group of students with whom to converse through e-mail ▪ The ability to ask experts questions through e-mail and video conferencing
Learning by Reflection	▪ Searching for information on the Internet encourages students to refine questioning abilities to find needed topics
Simulation-based Learning	▪ Computers able to run more sophisticated simulation to create more realistic results ▪ Internet allows for multiple students to participate in one simulation so that interaction with others within the simulation are possible

Based on Table 2.2, technology addresses two of the disadvantages of discovery learning, the required preparation and learning time and too large or too small classes. The preparation and learning time is greatly decreased by the Internet providing instant information and tools to use to prepare lessons. Computers address the problem of classes being too large by providing more student autonomy so that the student can ask questions and find answers without as much assistance from the teacher. E-mail and video conferencing address the problem of classes being too small because several classes of students can work together to create a larger body of collective experiences from which to pull previous information.

Technology can be used to compensate for some of the main disadvantages previously associated with discovery learning and simplify its use in the classroom. Technology has provided a source of information that gives society the freedom to change from a fact-oriented approach to learner to a process-oriented approach. For example, ten years ago, entire teams worked to maintain customer accounts and know what was ordered. Today a salesman in the field can know instantaneously everything about a customer and see what was ordered minutes before arriving at the office. No longer must the salesman focus on the customer order information. Instead the salesman can focus on how to get the customer to order more. Technology makes getting information easier than it has been previously and also has the potential to work well with discovery learning methods making it easier to use and, more importantly, making it a more effective strategy for learning.

2.3.4 Advantages of Discovery Learning versus Traditional Learning

There has not been a great deal of research done comparing the discovery learning method and traditional teaching. According to Castronova (2003), there appear to be four main areas of focus. These areas are motivation, retention, achievement and transference.

A significant advantage of the discovery learning method is its capacity to motivate students. Discovery learning allows learners to seek information that satisfies their natural curiosity. It provides the opportunity for students to explore their desires and consequently creates a more engaging learning environment. Simply put, discovery learning makes learning fun. In a study conducted, students learning through the discovery method were better organizers of information, more active in the task of learning, and more highly motivated than those who were taught in a traditional, lecture method.

In terms of information retention, discovery learning appears to be at least similar to the level found when using traditional teaching methods and possibly increases information retention. Alleman and Brophy in 1992 conducted research with college students by asking them to report memorable kindergarten through eighth grade social studies activities (Castronova, 2003). More students recalled activities that involved opportunities for experiential learning and higher order applications, characteristics of discovery learning, than activities that involved repetitive, low level seatwork. Students remembered more of what they learned in discovery learning activities than traditional activities. An older study also looked at the level of information retention among kindergarteners over a shorter timeframe.

Discovery learning increases student achievement when the students are learning skills rather than facts. Mabie and Baker in 1996 also showed an increase in achievement with their study of students learning about nutrition (Castronova, 2003). Mabie and Baker studied three groups of fifth and sixth grade students who were taught about food and fiber using three different methods. One group was taught over a 10-week period using garden projects. A second group was taught using short, in-class projects, and the third group was taught using traditional methods. Both the garden project and in-class project groups showed an improvement in pretest knowledge of 70-80% compared to an 11% increase in the group taught using traditional methods.

The fourth area of discovery learning versus traditional learning is transference. D. W. Chambers in 1971 did a study that compared discovery learning with over learning (Castronova, 2003). Over learning is a traditional method of drill and practice in which students practice a skill many times. Chambers found that students learning with the over learning method were better at transferring what they had learned than those who learned the concept through discovery learning. This study is greatly flawed due to the topic the students were learning which was rote memorization of math facts. Again, the fact that discovery learning does not work well with rote memorization impacted this study greatly.

2.3.5 Effective Discovery Learning

According to Reid, Zhang and Chen (2002), scientific discovery learning is a typical form of constructive learning based on problem solving activities involving the design and implementation of scientific experiments. Scientific discovery usually interpreted as the processes of mindful coordination between hypothesized theories and evidence collected by experiments. Scientific discovery learning is a knowledge construction approach that is based on the scientific discovery activities. Three main interlocked spheres exist in the processes of effective scientific discovery learning:

- Problem representation and hypothesis generation which heavily relies on the activating and mapping of prior knowledge and the meaning-making activities;
- Testing hypotheses with valid experiments; and
- Reflective abstraction and integration of the discovery experiences.

By taking all these perspectives in consideration, it is hypothesized that three interrelated conditions may determine the effectiveness of scientific discovery learning to great extent which is:

- The meaningfulness of discovery processes

  Students need to active their prior knowledge and map that onto the problem being addressed to help representing the problem and generating appropriate hypotheses and understanding.
- The systematic and logicality of discovery activities

  Effective discovery learning involves proper scientific reasoning, systematic manipulations of the variables and qualified designs and implementations of experiments.
- The reflective generalization over the discovery processes

  This feature involved self monitoring of the discovery processes and the reflective abstraction and integration of the discovered rules and principle.

Therefore, in a way that to develop effective Physics Virtual Learning and overcome the difficulties faced for discovery learning, the system must be designed according to the three hypothesized conditions stated before by helping students with knowledge access and activation, the generation of appropriate hypotheses, and the construction of coherent understanding besides adding experimental support that scaffolds Students in the systematic and logical design of scientific experiments, the prediction and observation of outcomes and the drawing of reasonable conclusions. Lastly, reflective support allows the students to increase their self-awareness of the learning processes and prompts their reflective abstraction and integration of their discoveries.

2.4 COMPUTER SIMULATION

2.4.1 What is computer simulation?

Computer simulations are programs that contain a model of a real system or a process. The learner's basic actions are changing values of input variables and observing the resulting changes in values of output variables. Originally, input and output of simulation environments was rather limited but now sophisticated interfaces were increased with direct manipulation as input and graphs and animation outputs are emerging with the latest development of virtual reality environment (de Jong & van Joolingen, 2000).

In this project, focus and concentration were given more on the use of computer simulation for learning. Firstly, it is because learning with computer simulation is closely related to a specific form of constructivist learning, namely discovery learning. Besides, simulation is found to be the most popular form of computer based learning environment used in higher education. In literature, a relatively high number of well documented simulation learning environments can be found.

2.4.2 Characteristic of Computer Simulation supported by Discovery Learning.

Discovery simulations have three general characteristic (Swaak & de Jong, 2001):

- **Rich**

  First, it is postulated that these types of learning environments can be described as rich environments. In a rich environment, a large amount of information can be extracted by the learner. This information can be obtained in several ways where the information usually displayed in one or more than one representation; a dynamic, graphical representation of the output is generally present next to animations and numerical outputs. More specifically, this latter component can be described as 'perceptual richness'

- **Low transparency**

  A second characteristic of simulation-based environments concern the relatively low transparency of the learning environment (as compared to text books or hypertext, etc.). The less transparent the discovery environment, the less the learner has a 'direct view' of the variables and relations, and consequently the more information is to be inferred or extrapolated.

- **Active interaction**

  The third characteristic of the learning context of this work involves the interactive aspect of the discovery simulations. The learning session entails an interaction with a simulation-based environment. Students are not supposed to passively absorb information on the domain from the computer screen, but rather they are expected to perform several different actions (i.e. do experiment) to make up their own 'meaningful' learning session.

2.4.3 Computer Simulations Enhance Conceptual Change

With the advent of computer technology, the potential to let students explore the world in cost effective and safe ways is no longer a difficult task. Recent studies indicated that computer has been implemented in restructuring learning environment where by the encouragement of higher-order thinking. In this prototype software, learner is viewed as an active participant in constructing his or her own knowledge rather than just merely being a passive process of receiving information or acquiring isolated pieces of knowledge. Learning involves altering one's existing conceptual framework in the light of new experience. Conceptual change is thus considered to be a process of progressively reconstructing mental representations of events in one's environment (Ting Choo Yee, 2000).

Educational conditions that promote conceptual change must firstly allow students to experience dissatisfaction with an existing conception (Ting Choo Yee, 2000). Secondly, the new conception must be intelligible. Thirdly, the new conception must be plausible and finally, the new conception must be fruitful. In order words, for conceptual change to happen, learners must make their own sense of imposed ideas, extracting meaningful patterns and integrating new input with their prior beliefs and ideas about how the world works. If the new ideas are better fitted to explain phenomena, then learners may abandon their prior ideas and use another set of conceptions.

Computer-based activities have an important role to play in promoting conceptual change. Interactive simulations are particularly useful because they enable users to explore and visualize the consequences of their reasoning. While computer simulations can of course never replace laboratory work, they do offer more in some ways by taking less effort to set up, are less dangerous, and they reduce demands on the student by providing automatic data logging and display facilities. They give instant feedback in the form of dynamic graphic or numerical representations of how variables are interrelated.

These facilities allow students to design and carry out a series of their own experiments, requiring a more sophisticated qualitative appreciation of the problem. In the context of this research, simulation environments can be used to clarify the implications of *Spring Phenomenon.* Besides, one of the beauty about computer simulation is this prototype software is that it allows user to change the rules through the formation of hypotheses in order to create 'alternative realities' or 'unrealistic phenomenon'. This allows the user to experience the consequences of breaking the physical laws, encouraging exploration and appreciation of their underlying logic. The 'unrealistic phenomenon' approach provides an opportunity for comparative testing of different modes (Ting Choo Yee, 2000).

2.4.4 Computer Simulation as Cognitive Tools

Research indicates that computer and its multimedia applications are said to have potential and cognitive tools (Ting Choo Yee, 2000). According to this view, student may adapt the technology for themselves and how they use it. The student-computer interaction, it is argued, they may develop and refine cognitive skills such as hypothesizing, reflecting, analysing, defining relationships, problem solving and other skills to aid and eventually enhance their learning abilities.

Computer simulations are extremely suited for this type of learning since they encourage discovery learning, learners experiment and construct knowledge as 'scientists' where by they provide the simulation with input, observe the output, draw their conclusions, and go to the next experiment (de Jong & van Joolingen, 2000)

Computer technologies as cognitive tools according to Ting Choo Yee (2000) must represent a significant departure from traditional conceptions of instructional technologies. In cognitive tools, information and intelligence is not encoded in the educational communications, which are designed to efficiently transmit that knowledge to the learners.

Throughout the researches on secondary school educational system, students only have few hours to obtain the experience on the lab experiment conducted and less time to understand the theories applied especially when they are working in a big group where each person has a small role in completing the task. Therefore, the idea on developing a computer simulation could help them in their learning process outside the schools.

The decision on developing a computer simulation based on discovery learning approach is because it's the best method in delivering scientific knowledge according to many researchers. Some of the data gathered for this project was from questionnaire that has been distributed to secondary school's students and teachers. This questionnaire is used to collect and gather information, opinion and feedback for the research work.
From the surveys on 100 participants around Serdang area in Selangor, the Author had come up with a few conclusions. The results from the questionnaire have been divided into several sections which will be explained below:

❖ **Interactive Multimedia (IMM) Application is suitable to be used both at schools and home.**

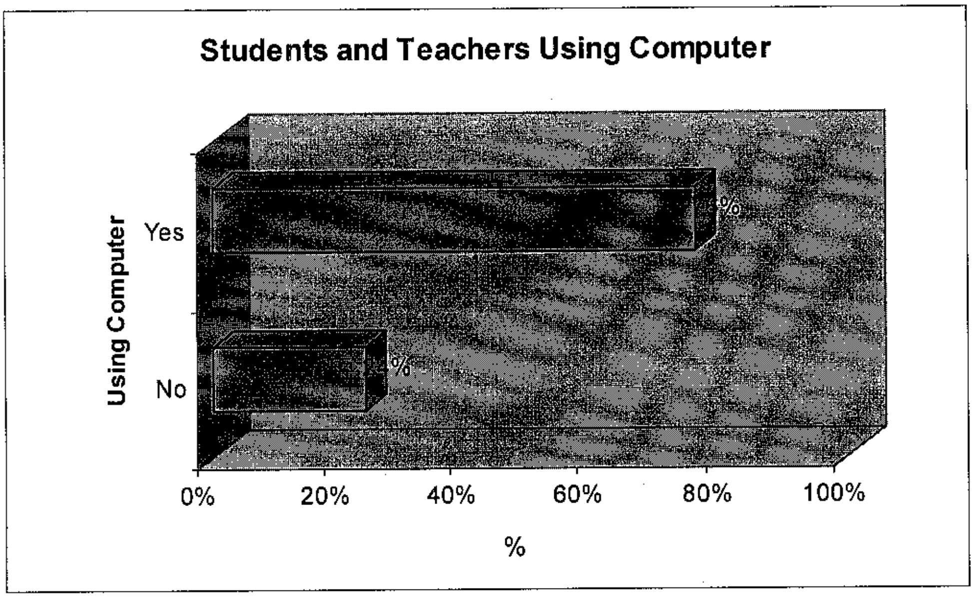

Figure 2.1 Students and Teachers Using Computer

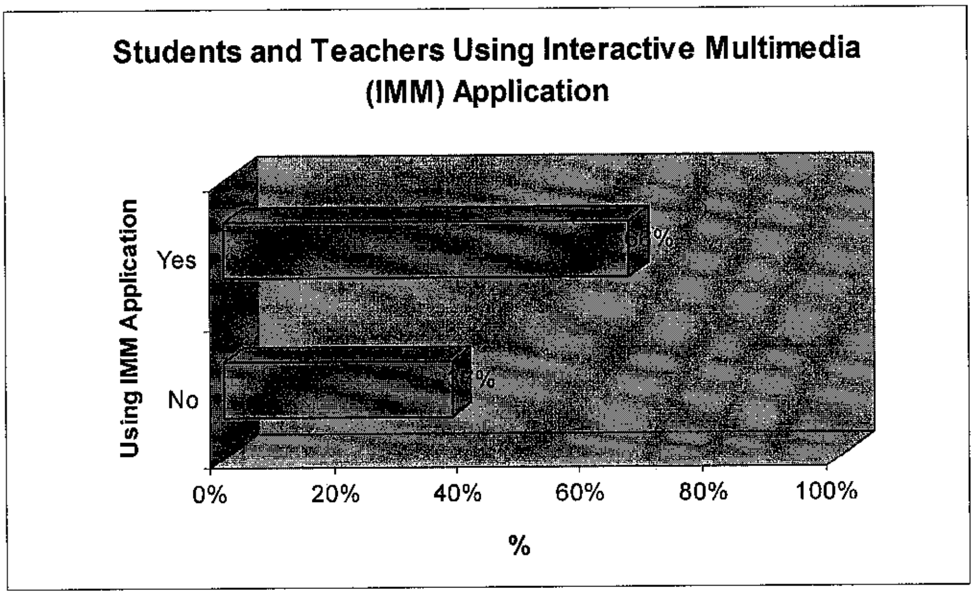

Figure 2.2 Students and Teachers Using Interactive Multimedia Application

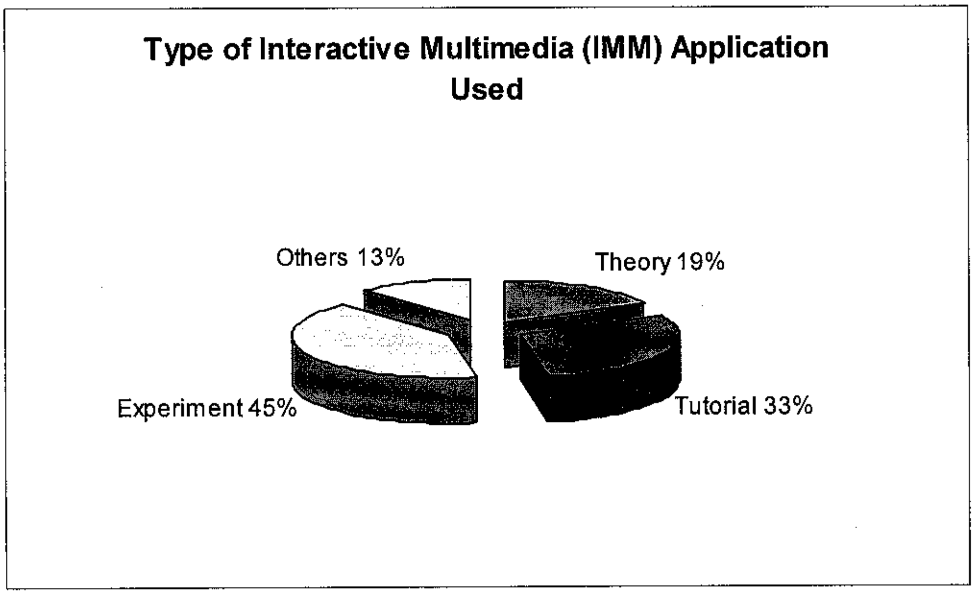

Figure 2.3 Type of Interactive Multimedia Application Used

From the Figure 4.1, the result shows that 76% of students and teachers used computer and 66% have used interactive multimedia application before, this showed in Figure 4.2. From the pie chart in Figure 4.3, the Author finds out that most of the students and teachers have used interactive multimedia application that related to experiment and tutorial.

According to the results, computer simulation is suitable to be used at school or home. This is because most of the students and teachers have computers at home and already have experienced in using several interactive multimedia application before. Students and teachers normally used computer to surf internet, play games and complete their related tasks. Both students and teachers have experienced in using interactive multimedia application related to theory, experiment and tutorials. Therefore, the Author finds that there are vast opportunities to introduce Physics Virtual Lab, a computer simulation as the new teaching material either at school or home.

❖ **Students and teachers need tools to aid them in the learning process**

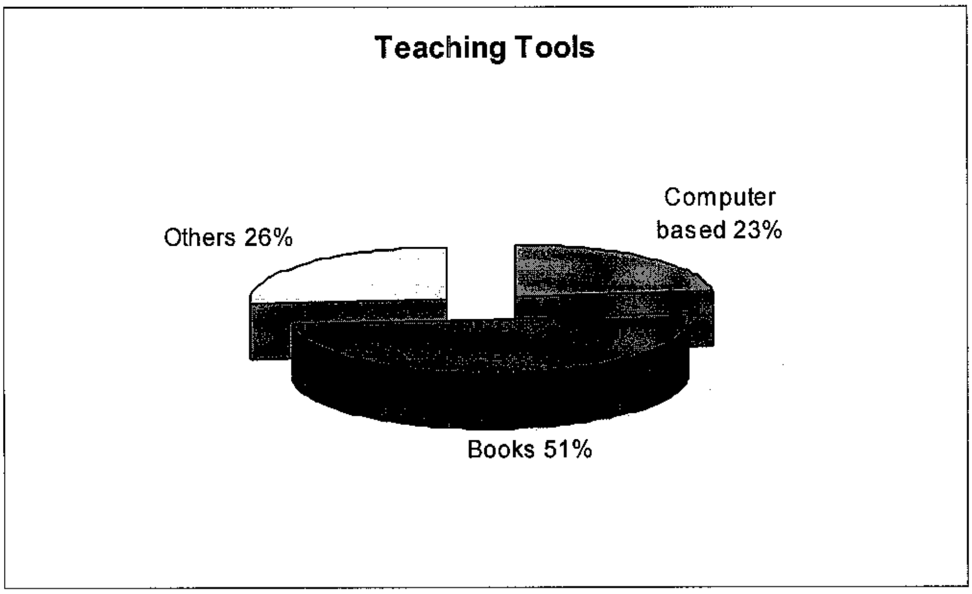

Figure 2.4 Teaching Tools

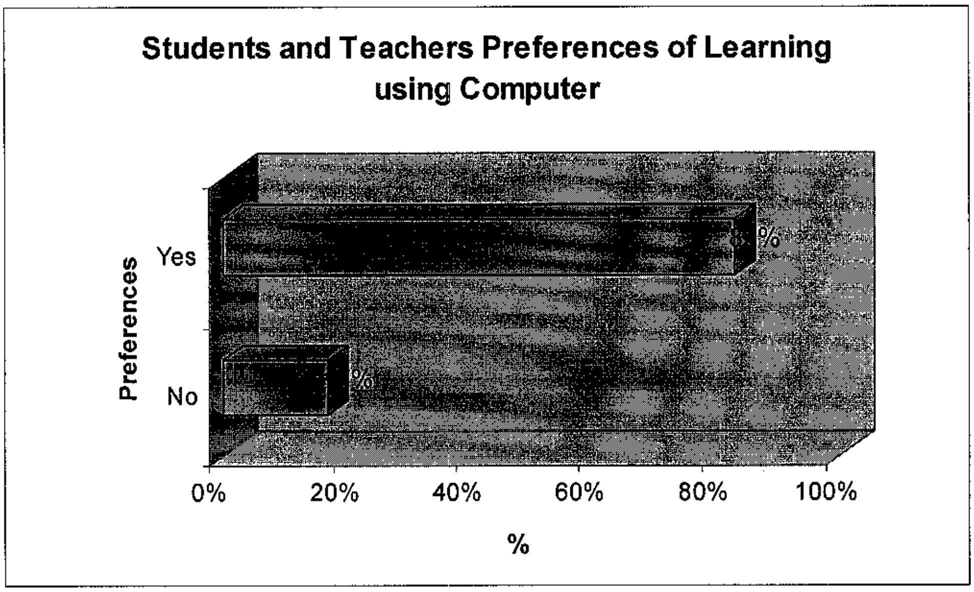

Figure 2.5 Students and Teachers Preferences of Learning using Computer

In Figure 4.4, most of students and teachers like to use books as their teaching and learning tools which is about 51%, 23% used computer-based and 26% used other tools such as objects, posters, cassette and video. In figure 4.5, it shows that 83% of students preferred or interested in using computer as their learning style. These results give positive feedback towards the development of this Physics Virtual Lab computer simulation.

The Author thinks that both students and teachers should do investment to assist their learning process. It is an advantage for them to use it as an option of teaching materials. This computer simulation is developed in order to allow students to have chances to get better understanding on theories implemented in the experiments.

- **The effectiveness of computer simulation for children**

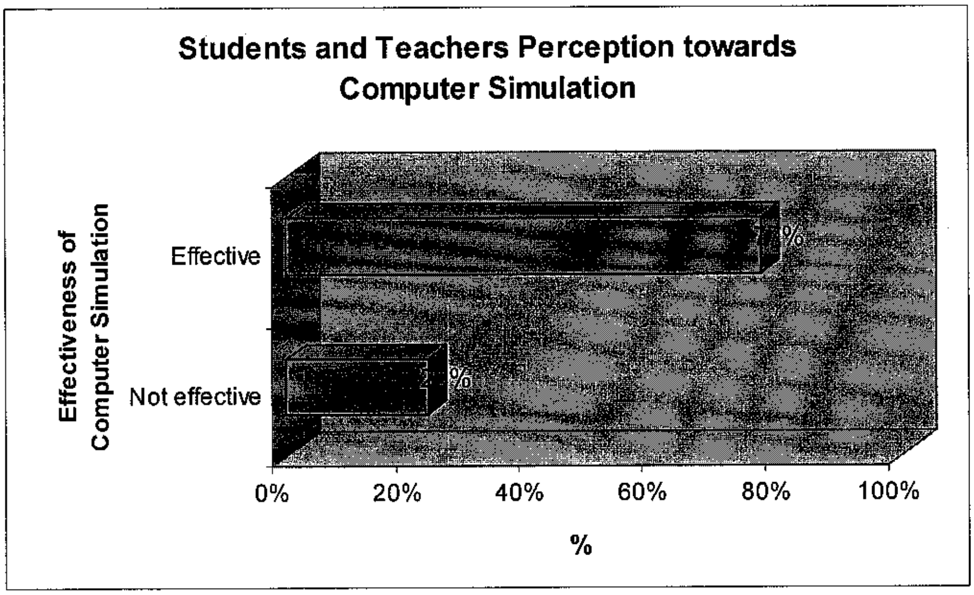

Figure 2.6 Students and Teachers Perception towards Computer Simulation

From the bar chart above, the Author finds that majority of students and teachers say that computer simulation is an effective way as a teaching tool assisting students in their learning process.

This result shows that students and teachers have positive perception towards computer simulation. The Author has made a conclusion that this Physics Virtual

Lab computer simulation is suitable to be used by students anytime, anywhere and not specifically during the lab hours. Students will have more time to run the experiments and play around with the variables in order to view different outputs.

- **Does discovery learning educational approach influence students learning process?**

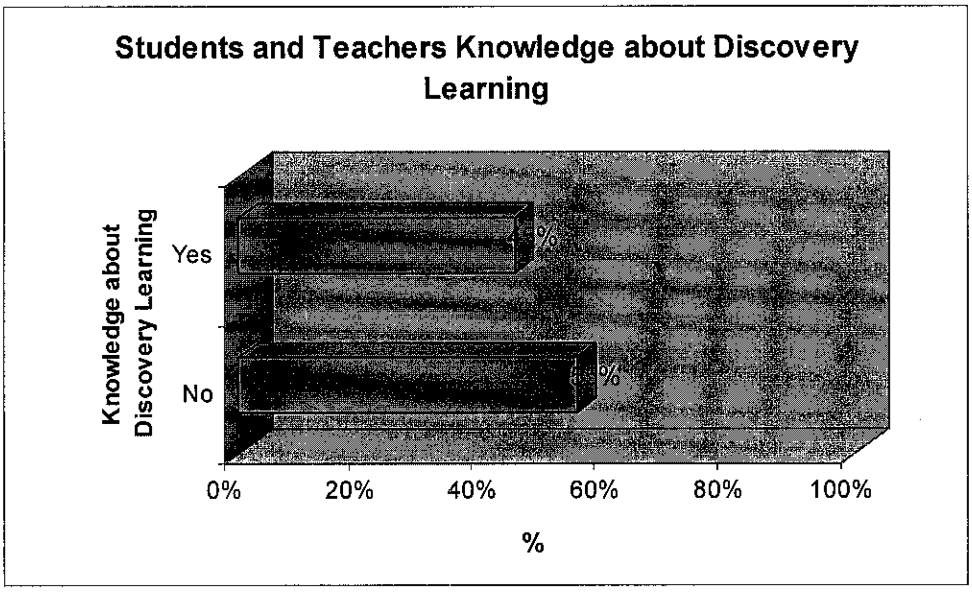

Figure 2.7 Students and Teachers Knowledge about Discovery Learning

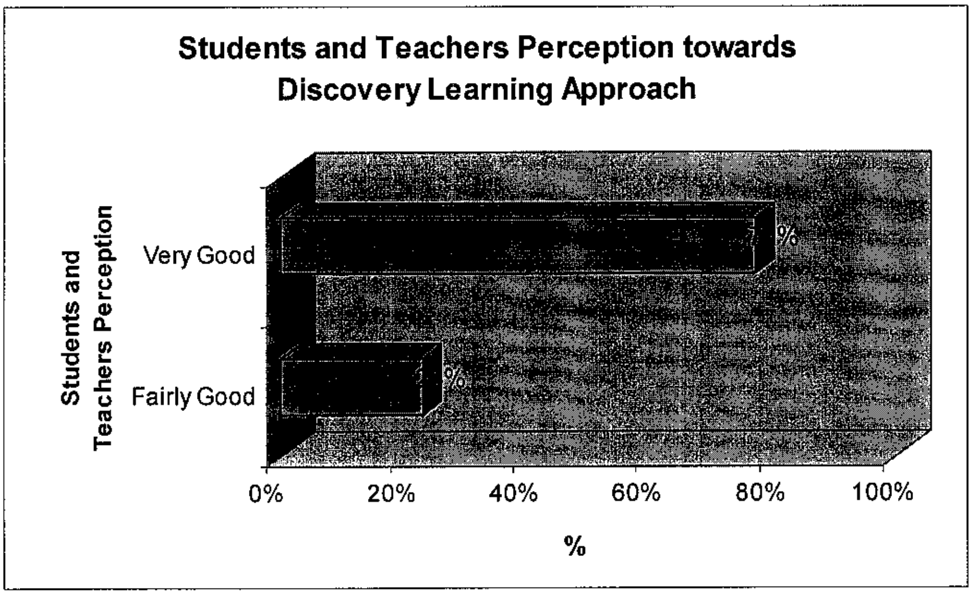

Figure 2.8 Students and Teachers Perception towards Discovery Learning Approach

In Figure 4.7, 55% students and teachers have not heard or do not know about discovery learning approach. Meanwhile in Figure 4.8, students and teachers who have the ideas what discovery learning is all about agrees that this approach is very good to apply.

The Author finds that almost participants agree with the ideas because:

- The students can improve their learning.
- Encourage students in thinking and applying theories in the activity.
- Easy to use, flexible, consistent and interactive.

2.5 VIRTUAL ENVIRONMENTS

2.5.1 Virtual Learning

It is only with the recent growth in the technology and the emphasis that the aerospace industry has placed on its value that has seen the growth in this technology for educational purposes. In fact, the success of virtual environments in areas such as pilot training has led to the development of virtual environments for other educational settings. (Jelfs & Whitelock, 2001). These types of environments offer students the opportunity for 'hands on' learning and the opportunity to meet situations where it is either too expensive or dangerous to allow students to try out the roles they want to learn. Physics Virtual Learning provides students with the experience and conditions in a very similar way to those realized in real labs.

The problem is to change the skills to be learned from hand-eye co-ordination tasks to content-based tasks, where one needs to know real information to accomplish one's goal on the computer (Jelfs & Whitelock, 2001). It represents that when a student is doing something that is fun, he or she can be learning a great deal without having to notice it. The same goes with this Physics Virtual Learning where with the attractive simulations, students are eager to learn and easy to understand. With the grafts, sounds and sliders just like the real physics machines available in the lab, this Physics Virtual Learning provided fun experience and meaningful knowledge. This learning method dramatically improves concept of retention. Students learn by employing the real process of conducting scientific research and at the same time become well informed about how it works.

Discussion on the role of presence, representational fidelity and control in designing effective learning environments and empirical studies have shown that students learning within virtual environments were affected by their notions of engagement, presence and previous game playing experience (Jelfs & Whitelock, 2001). The sense of presence can be interpreted in the notion of being physically present in the virtual world when it is presented to the user. There are several approaches that can be used in order to increase the sense of presence. To simulate the lab environment, real operations should be able to be imitated for example turning knobs, tuning dials, adjusting sliders to provide users with realistic experience and the sense of being in the real situation.

2.5.2 Virtual Laboratory

One of the most effective alternative solutions for higher education is the electronic laboratory. E-laboratories aim to fulfill the same function as traditional laboratories: to give students the opportunity to put the same practice their recently acquired knowledge and skills through unlimited and repeated use (Bermejo, Revilla & Cabestany, 2003). Due to e-implementation, the limits of time and space are not particularly restrictive for laboratory work. It is possible to carry out laboratory experiments in a structured or open-ended enquiry form, in which students develop manual, observation; problem-solving and interpretation skills in a similar way to researchers (Bermejo, Revilla & Cabestany, 2003). There are two different approaches to implementing an e-lab: virtual and remote laboratories.

In a remote laboratory, students can access the equipment of a physical laboratory through a web browser. Using a remote connection to real training environments, students acquire practical skills without damage to equipment or to themselves. Virtual laboratories, however, have no physical point of reference: student use a simulator that reproduces a real situation or implements a CAD tool. Virtual laboratories can be accessed in a straightforward manner through the use of applets embedded in HTML page. A considerable amount of applet repositories are freely available, and it is possible to build a virtual laboratory using these free resources.

CHAPTER 3
METHODOLOGY

3.1 PROCEDURE INDENTIFICATION

For this project, the author is going to implement the System Development Life Cycle Model (SDLC), Prototyping approach and Questionnaire and Observation for research method. SDLC is one of the structured approaches for information system development, created to guide all the processes involved, from an initial feasibility study through maintenance of the completed application. By dividing the development of a system into phases, each subdivided into more manageable tasks. Following such a methodology also prevents, to some extent at least, missed cutover dates and unexpectedly high costs and lower than expected benefits. At the end of each phase progress can be easily reviewed.

3.1.1 Software Development Life Cycle (SDLC)

In general, these are the phases involved in developing Physics Virtual Learning based on SDLC:

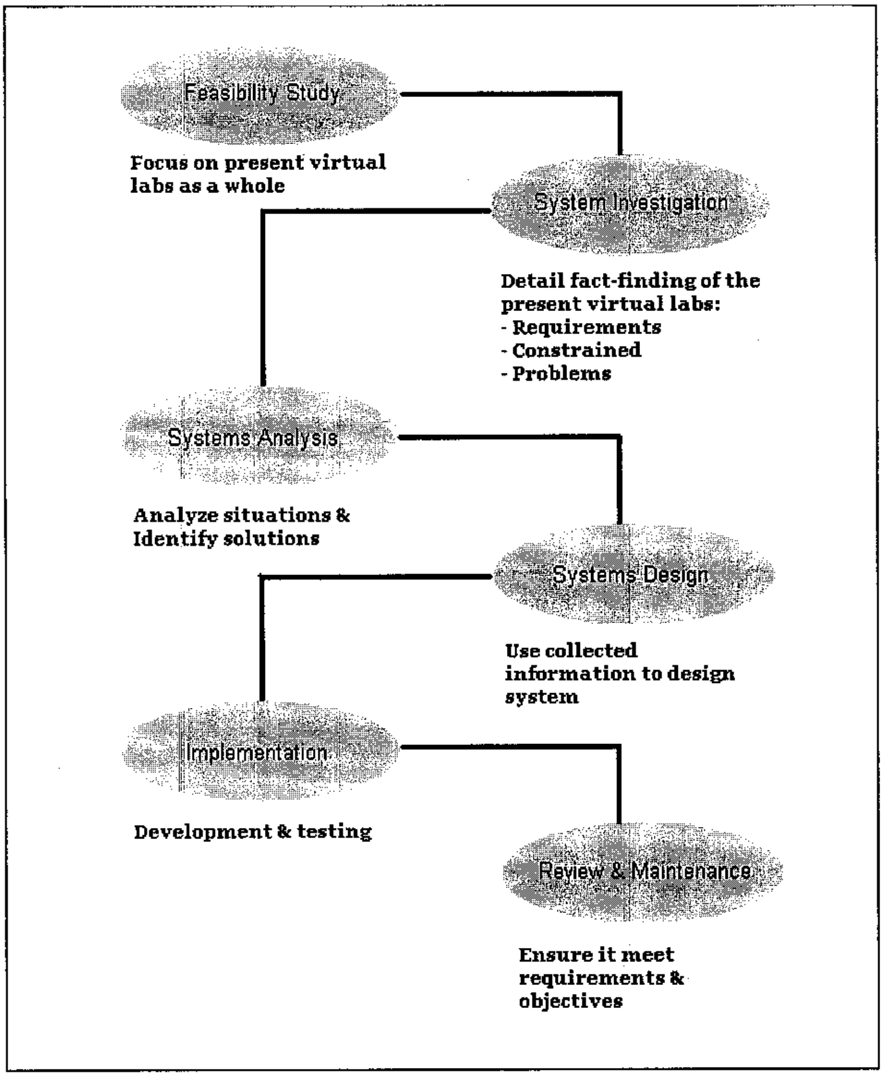

Figure 3.1 Software Development Life Cycle Model

- **Feasibility Study**

  Feasibility study looks at the present virtual labs, the requirements that it was intended to meet, problems in meeting these requirements, new requirements that have come to light since it was first implemented and briefly investigates solutions.

  Basically, the users need a new way in learning instead of using books as the main materials. Therefore with the completion of this computer simulation would give a new dimension in education whereby it's not only used to teach the students on the formal education, it also encourage them to learn on how to use the computer. The usage of computer will enhance the current style of learning where it only concentrates in classroom.

- **Systems Investigation**

  Systems investigation involved detailed fact-finding of the application area which look at the functional requirement of the existing system, the requirements of the new system, any constrained imposed, exception conditions and problems of the present working methods. The facts are gained through observation, searching records and documentations.

  The scope of the system is identified. From the researches done, it is believed that by implementing the animation in the development of the system would help the students in learning. This is because they could learn in an interactive way with the use of the system's attractive features. Besides, the user's requirements and the limitation of the current system are identified too.

  From other point of view, learning should be fun and interesting, therefore by developing this computer simulation will enhance student learning in term of cost, time and effectiveness.

- **System Analysis**

  After the completion of the first stage, the process of developing the system is proceeding to the next phase, which is analysis. Analysis is a detailed study of the various operations performed by a system and their relationship within and outside the system. These stages involved a detailed study of current system, leading to specifications of a new system. In user requirements phase, the subject on what the users requires from the system being developed and established. During this stage, the data about the present system in educating the students are collected together with the solutions for the limitation arise. Questionnaires and researches on available sources on the Internet are the tools used during this stage.

- **Systems Design**

  This stage involves the design of both computer and documentation part. Used the information collected earlier to accomplish the logical design of the system. The design is specific to the technical requirements the system will be required to operate in and the tools used in building the system. The information on where the content should reside in the system being developed, how to construct interface and navigation and what are the best software to be used were determined.

  The Author developed a flowchart diagram to depict structure of the simulator. Then the Author designed the storyboard to get the layout of the elements to be displayed on the screen and the allocation of the buttons, texts, graphics, pictures and animations.

- **Implementation**

  This is the stage where the courseware is implemented. All units are combined and the whole system is tested. When the combined programs are successfully tested, the development of the courseware is likely to be finished. During testing, the system will be executed with some selected data to uncover the errors that might which occur in which error is a mistake by the designer that led to fault.

- **Review and Maintenance**

  The final stage in the system development process occurs once the system is operational. There are bound to be some changes necessary and maintenance needed to ensure the continued efficient running of the system. There will also be a review of the system to ensure it does conform to the requirements laid out in the feasibility study.

3.1.2 Prototype Approach

There are two interrelated main concerns on issues about going through the SDLC; first concern is the extended time required to go through the development life cycle. As the investment of analyst time increases, the cost of the delivered system rises proportionately. Second concern is on the user requirements which changed over time.

To overcome these problems, prototyping is an approach used to complement the SDLC model. It effectively shortens the time between ascertain of information requirements and deliverable of workable system. With prototype, users can actually see what is possible and how their requirements translate into hardware and software. It can increase creativity because it allows quicker user feedback which can lead to better solutions.

3.1.3 Questionnaire and Observation

Questionnaires are the method on collecting information besides observation. The questions are prepared in general where there are no specific questionnaires either for the teachers or for students to find out their opinion on exposing the students to Physics Virtual Learning supported with discovery learning. From the questionnaire conducted, it seems that most of the respondents have the same thoughts on using computer simulation as one of the learning tools *(refer to Appendix B).*

Internet is an essential information resource in fact finding whereby it has the ability to make survey and research on current issues of education. The study on the available sources such as researched paper, journals and articles are providing lots of information on the development of Physics Virtual Learning. There are also existing virtual labs focusing on physics, chemistry and biology available on the Internet. Detailed study and observation of the current system provided on the internet lead to specifications of new enhanced system that fulfill the need of students.

3.2 TOOLS USED

3.2.1 Hardware Requirement

The list of hardware that will be needed at least to fulfill the system development are as follows:

- At least 400MHz processor speed 500MHz recommended
- 64MB RAM 128MB recommended
- 10GB hard disk space (include window and basic software)
- 40x CD-ROM speed for easy installation
- 8MB of VGA (to support the animation)
- Soundcard
- CD Writer

3.2.2 Software Requirements

The lists of software that will be used for developing the Physics Virtual Learning are as follows:

- Easy Java Simulation 3.1

  Easy Java Simulation is software tools designed for the creation of discrete computer simulations.

- Java Development Kit 1.4

  Java Development Kit is the compiler used for Java program.

- Adobe Photoshop 7.1

  Comprehensive tools to create sophisticated images for print, the Web, wireless devices, and other media and complete image-editing task efficiently

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 OVERVIEW

The prototype on the Physics Virtual Learning performs as expected. This chapter will explain the result of functional and integration testing together with the screen shots of the system and its descriptions.

4.2 FUNCTIONAL TESTING

Each subsystem is tested once it is developed in order to detect and debug any flaws before it is made up as a whole system. It is also to ensure each subsystem is well-functioning. All subsystems are tested using functional testing which aims to achieve expected result from the respective input. For this system, functional testing is focusing on the experiment modules as they provide several functions for the user to control and monitor the experiments. Test results are described in Table 4.1

Table 4.1: Test Result for Basic Spring and Advanced Spring Experiment Module

Component	Expected Test Result	Actual Test Result
Play button	▪ Starts the evolution of the simulation	▪ Successfully started the simulation.
Pause button	▪ Stops the evolution of the simulation	▪ Successfully paused the running simulation.
Reset button	▪ Initializes all model variables to the values set in the tables of variables. ▪ Executes the pages of initialization code and clears the view ▪ Brings back the simulation to its exact initial state	▪ Successfully set back the simulation to its exact initial state.
Step button	▪ Executes one step of the evolution of the simulation	▪ Successfully execute one step of the evolution of the simulation.
Slow button	▪ Controls the number of milliseconds that the experiment must wait when it finishes one step of the evolution before executing the next one. ▪ Decreases the number of frames per second of the simulation.	▪ Successfully slowed down the evolution of the simulation observed by users.
Fast button	▪ Increase the number of frames per second for the simulation. ▪ Fasten the evolution of the simulation.	▪ Successfully fastened the evolution of the simulation observed by users.

Each subsystem is functioning as expected; the whole system is functioning well without much redesign need to be made.

4.3 INTEGRATION TESTING

Integration testing will be conducted when each subsystem completely developed and when all subsystems are combined as a whole. It is to ensure that there is no flaw or error every time integration of subsystems is performed. It is also to ensure that the system is well-functioning as a whole. In case of error found, debugging will be carried out. Under this testing, the system linkages are also being tested. It is to ensure each link or hyperlink in the system is well-functioning. Besides, the testing also aims to ensure the successfulness of the connection between the system and Easy Java Simulation components. Test results are describe in Table 4.2

Table 4.2: Test Results of Integration Testing

Module/ Component	Expected Test Result	Actual Test Result
Integration between Subsystems	▪ To ensure the integration between subsystems is successful without any flaws or errors. ▪ To ensure each subsystem is well-functioning.	▪ Successfully integrated and each subsystem is well- functioning.
System as a Whole	▪ To ensure that the system is well-functioning. ▪ To guarantee there is no flaw or error after integration of all subsystems.	▪ The system is functioning successfully. ▪ Successfully guaranteed there is no flaw or error after the integration.
Linkage between subsystems	▪ To ensure user can go (jump) to another subsystems directly.	▪ Each subsystem is successfully linked and allowed user to go to another subsystems directly.
System and Easy Java Simulation	▪ To ensure the connection between the system and Easy Java Simulation component is successful.	▪ The connection is successful.

4.4 SCREEN CAPTURES AND DESCRIPTIONS

Following are screen captures of the interfaces in the system and description of the objective for each interface. This Physics Virtual Learning involved the physics theory for spring phenomenon which consisted of two modules; Basic Spring and Advanced Spring.

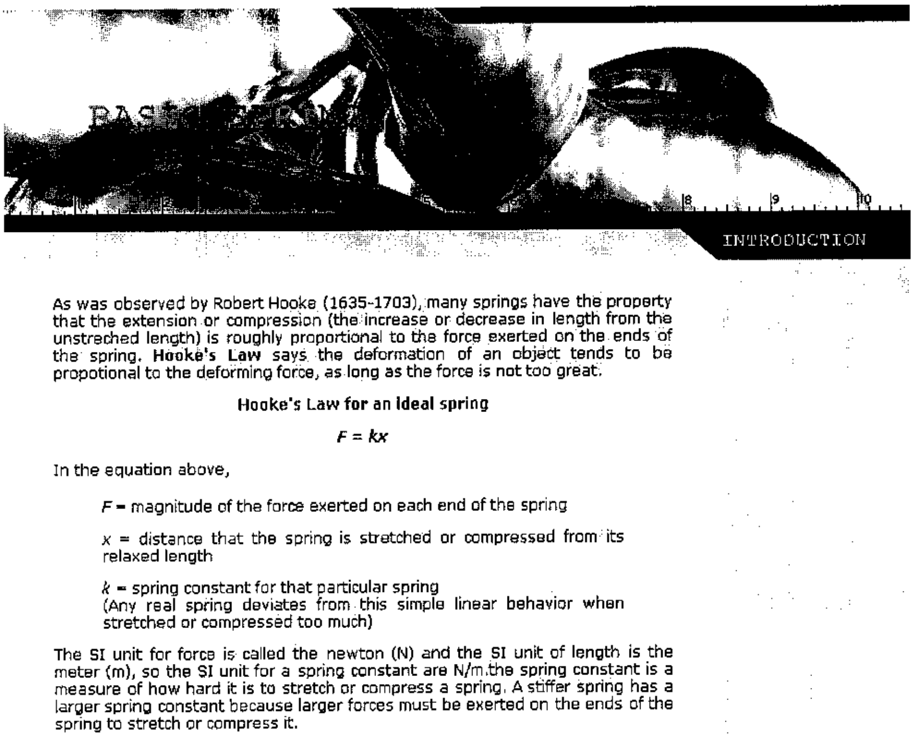

Figure 4.1: Introduction of Basic Spring Module

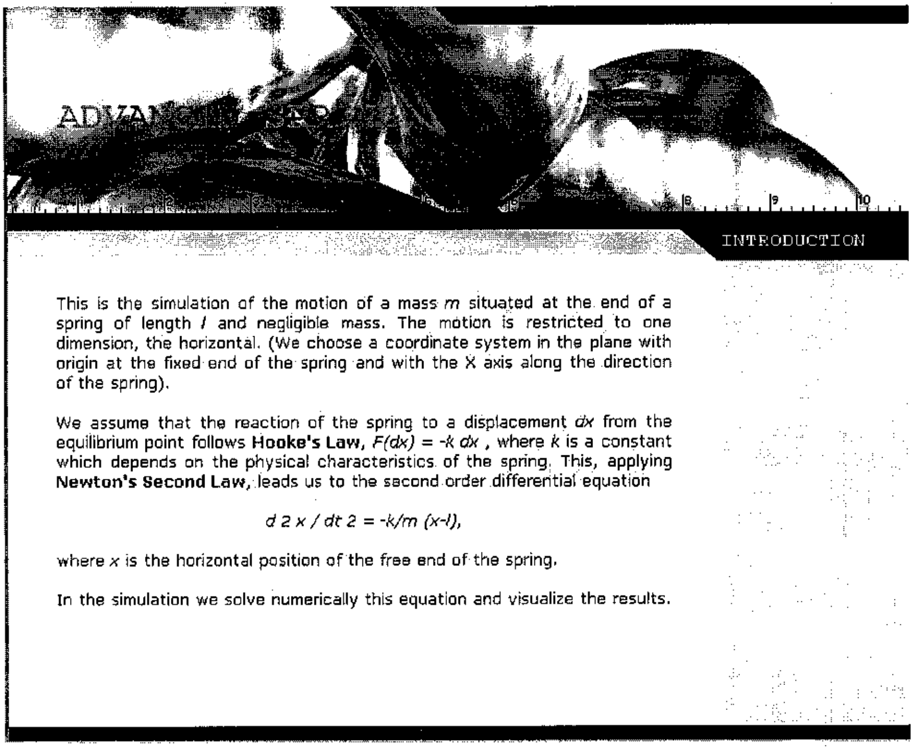

Figure 4.2: Introduction of Advanced Spring Module

Figure 4.1 and Figure 4.2 show the introduction page for Basic Spring module and Advanced Spring module. These pages consist of some introduction to the physics phenomenon and related physics theories. They aim to provide sufficient knowledge for students at the first place in order to gain better understanding as preparation before doing the experiment. From this knowledge, students will easily understand the problem and generate the hypotheses which heavily rely on the activating and mapping of prior knowledge and the meaning-making activities. In the introduction also included the equations of each theories and variables pertaining to the equations. Students need to master these variables and equations as later on they need to observed the experiment and prove that their hypotheses is true.

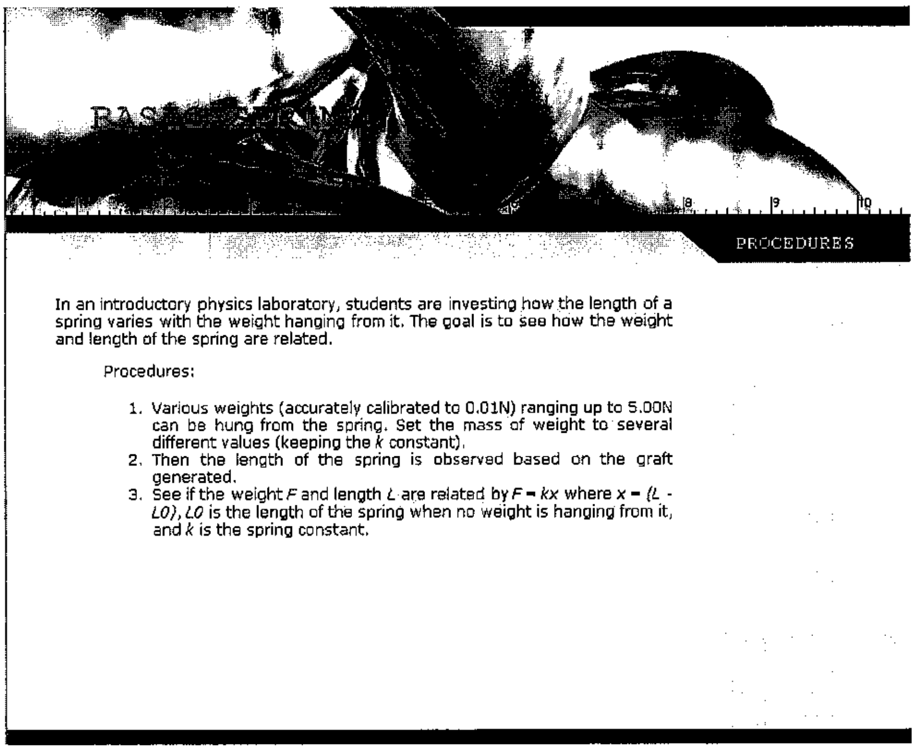

Figure 4.3: Procedures of Basic Spring Module

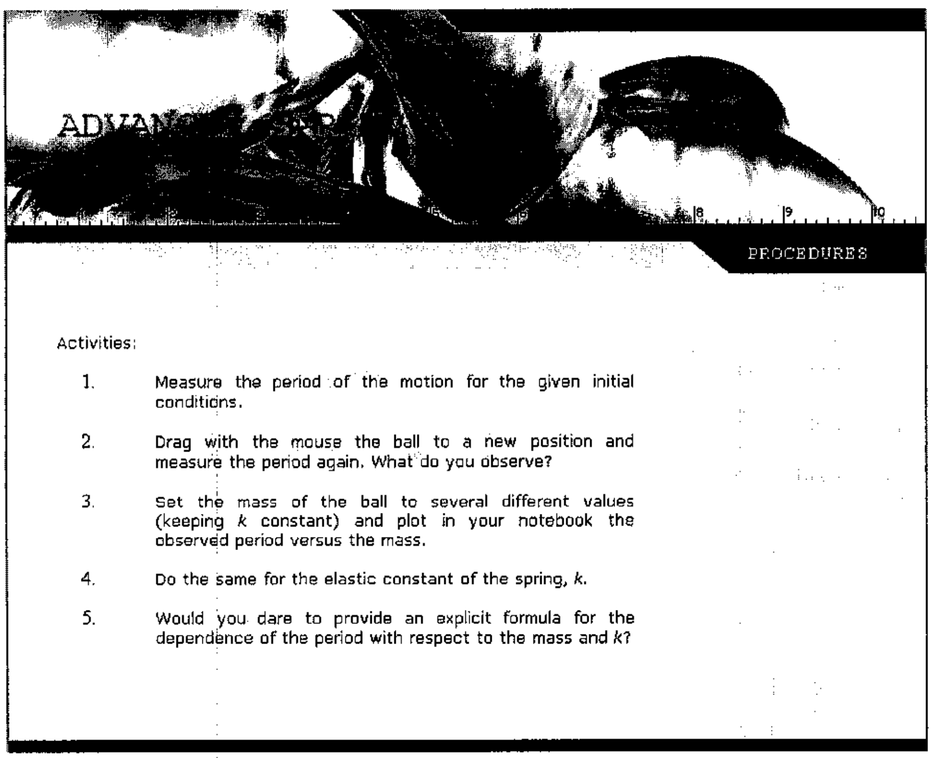

Figure 4.4: Procedures of Advanced Spring Module

Figure 4.3 and Figure 4.4 show the procedures for each Basic Spring module and Advanced Spring module. These procedures help students to visualize the variables and factors that influenced the theories and hypotheses. Students need to clearly understand the procedures so that they will know steps to be done for the experiment. The systematic and logicality of the experiment procedures are parts of the effective discovery learning which involves proper scientific reasoning, systematic manipulations of the variables and qualified designs of experiments. Through these procedures, student will automatically get the idea to relate the equations and the variables and capture the relationships between them.

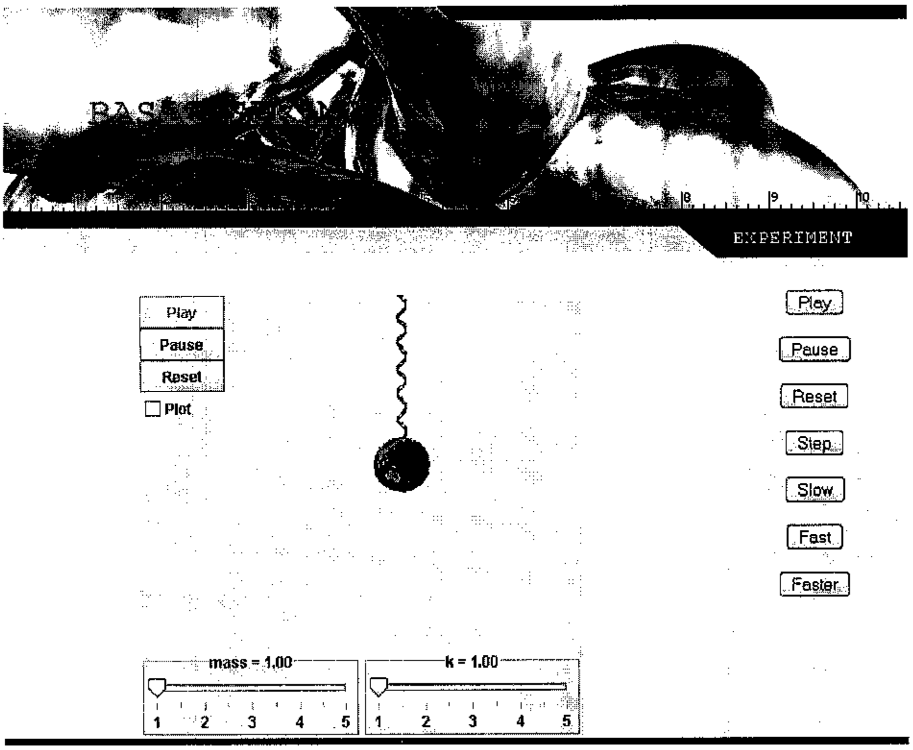

Figure 4.5: Experiment of Basic Spring Module

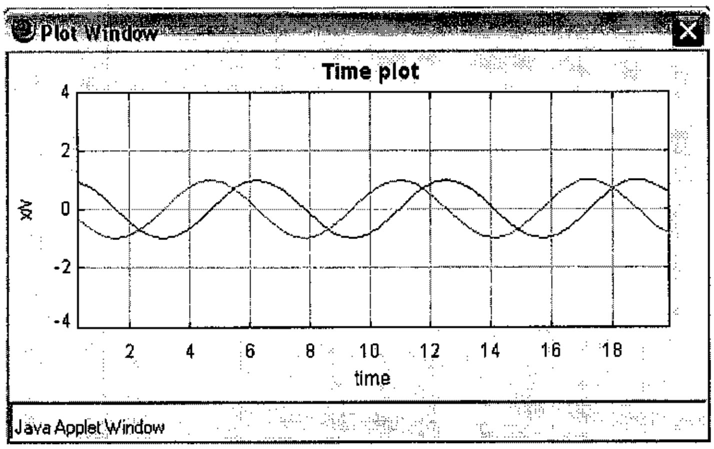

Figure 4.6: Graft Generated from Basic Spring Experiment

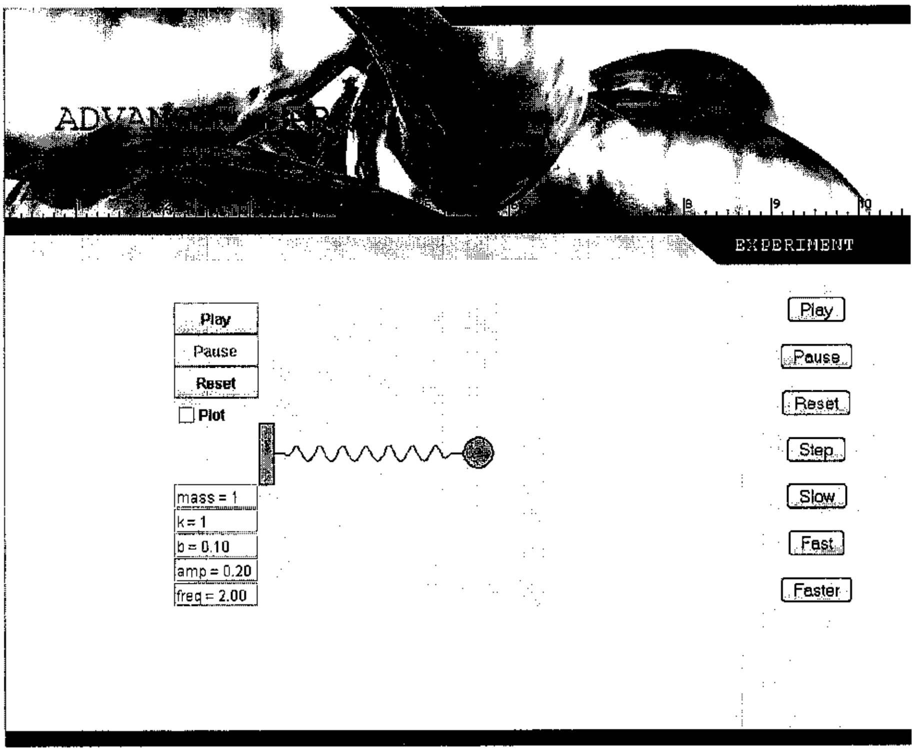

Figure 4.7: Experiment of Advanced Spring Module

Figure 4.5 and Figure 4.7 show the experiment designed for Basic Spring module and Advanced Spring module. These experiments aim to scaffold students in the systematic and logical design of scientific experiments, the observation of outcomes and the drawing of reasonable conclusions. Students are allowed to manipulate the variables involved in the experiments and perceive the consequences of the manipulations in dynamic outputs. Students are required to predict the outcomes and compare their prediction against the observations after the experiments. The conclusion of the discovery against an experiment structure is represented in interactive graft as shown in Figure 4.6. The buttons available by the side of the experiment allow the students to control the evolution of the simulation.

CHAPTER 5
CONCLUSION

5.1 CONCLUSION

This paper presented the design and development process of a virtual laboratory environment and a prototype for the Physics Virtual Learning. Basically it allows students to perform experiments and can be regarded both as an extensible system for creating dynamic, interactive science laboratories, tutorials for building scientific models of physical systems and as instrumentation which can be used to investigate both general and discipline-specific learning issues and questions.

With this approach, it will be lightly to reduce some problems related with the traditional labs such as cost, time and distance education. This Physics Virtual Learning can fill a need for hands-on labs for distance education especially for science and engineering based courses for which laboratory experimentation is indispensable. Now, students can perform experiments at any time and location since the labs are available online for 24 hours a day.

From the research point of view, this Physics Virtual Learning has study the effectiveness of discovery leaning theory for science subject compared to other traditional learning system. Finally, it is hope that the development of this system will help to improve the higher learning institutions in Physics course.

5.2 RECOMMENDATION

There are few recommendations that can be done to the system so that it can be expanded in the future to be more reliable and practical. For future development, it is suggested that the content should be expanded, means that this simulation should be developed based on the learning scope. As this simulation is just a prototype, the Author may not have enough time to cover all the physics theories.

In term of the experiment, the simulation can adopt paired-instance design that requires learner to construct a pair of experiments at a time, so that they could contrast the outcomes of two instances conveniently.

In order to ensure student understanding in each theory, exercises or quizzes can be added as extra activity. It would help the student to capture the knowledge and apply them appropriately. In the design development, the Author would try to apply some interactivity approach to retain students' attention.

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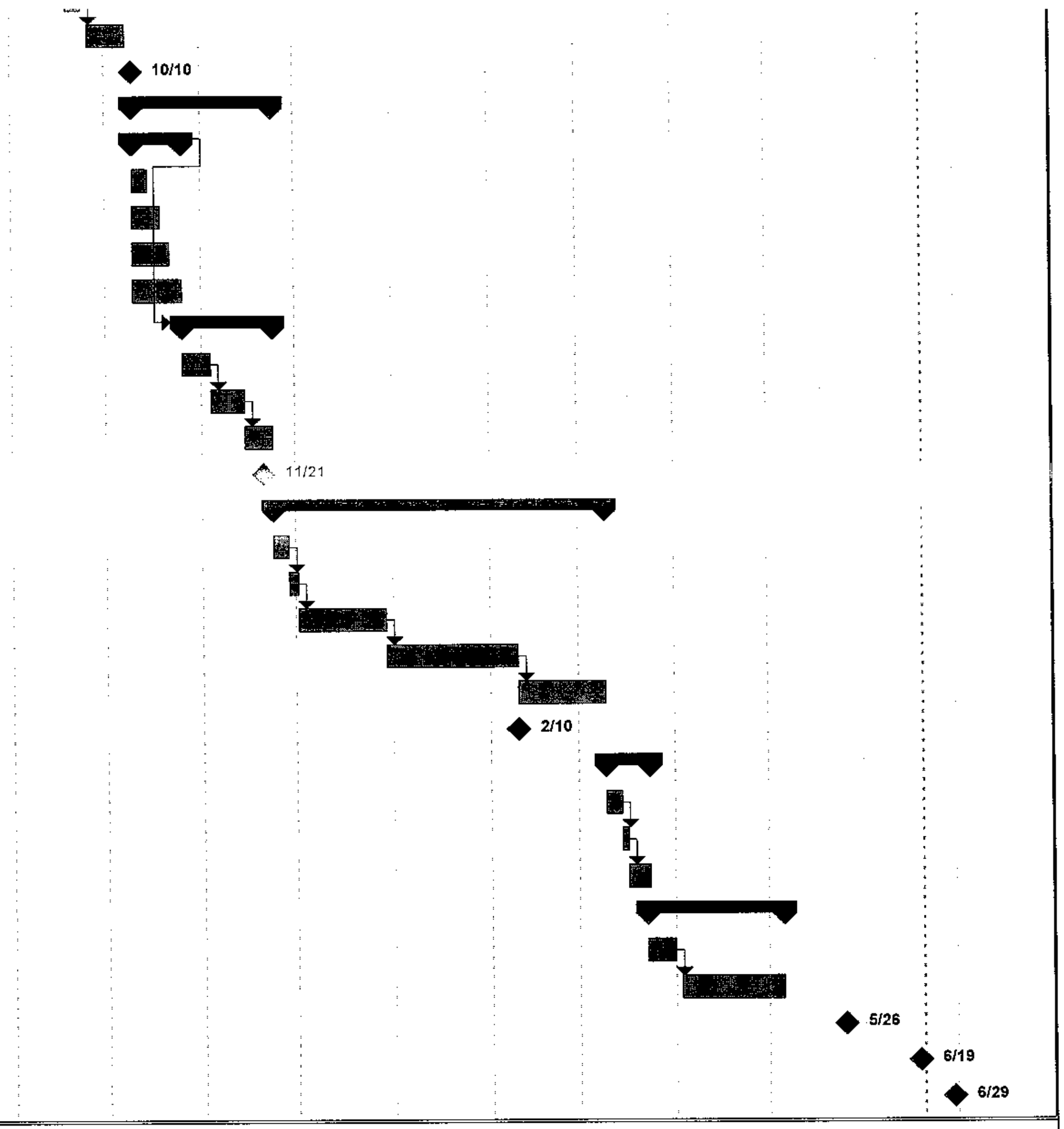
APPENDICES

APPENDIX A
GHANTT CHART

ID		Task Name	Duration	Start
3		System Investigation	10 days	Mon 9/26/05
4		Submission of Preliminary Report	0 days	Mon 10/10/05
5		**System Analysis**	**33 days**	**Mon 10/10/05**
6		**Gather information and data**	**12 days**	**Mon 10/10/05**
7		Discovery learning and other theories	5 days	Mon 10/10/05
8		Computer simulation components	7 days	Mon 10/10/05
9		Questionnaires	10 days	Mon 10/10/05
10		Refer to researches done	12 days	Mon 10/10/05
11		**Define Requirement**	**21 days**	**Wed 10/26/05**
12		Define user requirements	7 days	Wed 10/26/05
13		Define content requirements	7 days	Fri 11/4/05
14		Define specific functionality	7 days	Tue 11/15/05
15		Submission of Interim Report	0 days	Mon 11/21/05
16		System Design	76 days	Thu 11/24/05
17		Design flowchart	3 days	Thu 11/24/05
18		Develop storyboard	3 days	Tue 11/29/05
19		Develop interface and background	20 days	Fri 12/2/05
20		Develop experiments model	30 days	Fri 12/30/05
21		Develop navigation and link	20 days	Fri 2/10/06
22		Submission of Progress Report	0 days	Fri 2/10/06
23		**System Implementation**	**10 days**	**Fri 3/10/06**
24		Conduct testing	3 days	Fri 3/10/06
25		Training users	2 days	Wed 3/15/06
26		Get user feedback	5 days	Fri 3/17/06
27		**Review and Maintenance**	**32 days**	**Thu 3/23/06**
28		Debugging	7 days	Thu 3/23/06
29		Improve and Enhance	25 days	Mon 4/3/06
30		Submission of Disertation Final Draft	0 days	Fri 5/26/06
31		Oral Presentation	0 days	Mon 6/19/06
32		Submission of Project Dissertation	0 days	Thu 6/29/06



Project: Project1
Date: Tue 6/20/06

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

APPENDIX B
QUESTIONNAIRE

Project Title: Physics Virtual Learning

A Feasibility Study of Psychological Impact on Discovery Learning Method

Questionnaire

Abstract:

This is a survey intended for research purposes. The target audiences are secondary schools students and this questionnaire will be filled by them and the teachers. This questionnaire is used to collect and gather information, opinion and feedback for the research work. It is hope that, from this survey the author will come out with interactive computer simulation with real lab experience using discovery learning approach. Computer simulation is educational material intended as kits for teachers or as tutorials for students, usually packaged for use with a computer. This project is about developing a computer simulation for virtual learning which are not only emphasizes on teaching but also developing their ability in practical skills.

Kindly please answer all the appropriate question.

1. You are…

   ☐ Student

   ☐ Teacher

2. Do you have computer in your home?

   ☐ Yes

   ☐ No

3. How did you use your computer?

   ☐ Work on related tasks

   ☐ Playing games

   ☐ Surfing Internet

4. Do you use any teaching tools in the learning session?

   ☐ Yes

   ☐ No

5. What type of teaching tools?

   ☐ Computer-based

   ☐ Book

   ☐ Others

6. Do you prefer learning using computer?

   ☐ Yes (If yes, go to Question 7)

   ☐ No.

7. Have you used any computer simulation that available on the Internet or in the market?

   ☐ Yes (If yes, go to Question 8 onwards)

☐ No

8. How do you find computer simulation in helping students in their learning process?

   ☐ Effective

   ☐ Not effective

9. Have you heard about discovery learning approach?

   ☐ Yes (If yes, go to Question 10)

   ☐ No

10. How do you find discovery learning approach?

    ☐ Fairly good

    ☐ Very good

Thank you for your cooperation.