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Study of the Effectiveness of a Web-based Interactive Homework

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STUDY OF THE EFFECTIVENESS OF A WEB-BASED
INTERACTIVE HOMEWORK

By

Jie Liang

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Physics
in the Department of Physics and Astronomy

Mississippi State, Mississippi

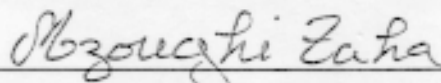
May 2002

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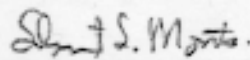
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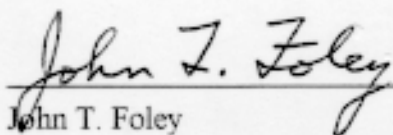
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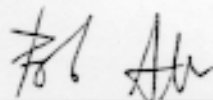
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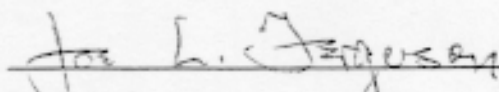
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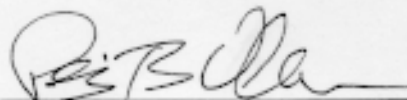
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Candidate for Degree of Master of Science

With increased use of the web in teaching there is growing interest in the effectiveness of web-based tools in facilitating student learning, I have conducted a case study on the effectiveness of web-based tutorial alternative. I designed a web-based homework tutorial about two-dimensional kinematics and conducted two experiments to evaluate its effectiveness. The evaluation focused on student's performance and attitude.

In Experiment 1, the experimental group and control group worked with the interactive web-based and regular homework respectively. Both groups worked at home. In Experiment 2, the experimental group worked with the interactive web-based homework used in Experiment 1 in a lab setting. The control group in Experiment 2 worked on the same homework problems as the control group of Experiment 1 but via computer in a lab. The evaluation indicated that the interactive web-based homework

could be considered as an alternative to the general homework. Moreover it appeared to strengthen attitudes and encourage more students to complete the assignment.

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Chapter I

INTRODUCTION

1.1 Background

Research has shown improved student learning when meaningful homework assignments are completed and returned to students with constructive comments [1]. Homework is usually given to complete unfinished class work, provide additional practice, use outside resources, and learn topics related to the ones covered in class [2]. Student benefits from completing homework include learning to work independently and developing self-discipline and responsibility [3].

On the other hand, especially in large enrollment university classes, time constraints often lead frustrated teachers to either not assign homework or just assign "busywork" type problems. Feedback, when provided, is often delegated to inexperienced graduate or undergraduate assistants [4].

To overcome these shortcomings many teachers have started using the Web in delivering homework. Several companies and universities are capitalizing on this need and are providing software for homework delivery.

1.1.1 Use of the Web in Delivering Homework

Some members of the faculty in the physics department at Mississippi State University use the Homework Service of the University of Texas [5] for Web homework delivery. The homework problems assigned through the service are typical end of chapter problems. Each student receives a unique homework version. They login to retrieve their homework and work on it offline. They are required to submit answers online and are allowed to resubmit questions they have not answered correctly. They can retrieve a fully worked out solution of the homework after the due date.

CAPA [6], created by the University of Michigan, is another homework delivery system widely used by physics teachers. The wide use of CAPA has allowed it to build a large database of problems authored by teachers from all over the English-speaking world. For the most part, these problems are similar to typical end of chapter problems. The current version of CAPA allows teachers to embed simulations in problems.

Another popular homework delivery service among physics departments is North Carolina State University's WebAssign [7]. This system provides access to the actual end of chapter problems for most physics books in use in the US. Teachers can add their own questions and can embed simulations and video in the problems. Teachers have the option to provide students with detailed solutions.

Other examples of homework delivery services include course management systems like WebCT and BlackBoard [6]. Most of these systems simply provide a mechanism to deliver traditional text-based homework. Major publishers provide compatible content to teachers who adopt their books. Teachers can use the additional features of the software to provide students with examples and solutions.

In addition to the popular homework delivery systems described earlier some faculties have developed or used other methods. For instance, Chuck Bennett [8] from the University of North Carolina in Asheville has developed his own utility, WebHW, to deliver homework problems. The problems used are typical end of chapter problems and are divided into one or more subparts. Each subpart may consist of one or more numeric inputs and multiple-choice questions. The numbers used in the numeric parts are generated randomly. Students must work every subpart before earning points. They are allowed to make an unlimited number of submissions. Bennett observed that most of his students never give-up on a problem until they get it right. The average homework grade they have received when using WebHW is around 90%. He also noted the students' test scores have improved since he started using WebHW. Similarly, Woolf et al. from the University of Massachusetts have developed an online web-based learning (OWL) system to deliver electronic homework [9]. OWL has the distinction that in addition to being an online quizzing system, it also serves as an interactive learning environment. This is accomplished by providing Guided Discovery Exercises and intelligent tutoring. In Guided Discovery Exercises students interact with multimedia simulations or visualization activities and use them to "discover" the basic laws and concepts addressed. Intelligent tutors provide students with individual instructional strategies.

1.1.2 Interactive Engagement

Parallel to the growth of popularity of the use of homework delivery systems, a move to reform introductory physics courses for scientists and engineers has been taking place. Of particular interest is what is referred to as the use Interactive Engagement (IE) methods. These methods are defined as heads-on and hands-on activities that require the

students to experiment, discover, and discuss findings with fellow students and teachers. On tests made on more than 6000 students taught by different faculty and different institutions, Hake [10] has shown that students who take IE courses score higher on the Mechanics Diagnostic test and Force Concept Inventory (FCI) than students who take traditional courses.

An example of these IE methods is the Interactive Lecture Demonstrations [11] model promoted by Sokoloff from the University of Oregon. In this model, carefully chosen demonstrations are shown to class. The students are then asked to write a prediction on the outcome of the experiment. They are then asked to engage in-group discussions and to update their predictions. The experiment is then completed and the students are asked to reconcile their observations with their predictions.

Another example of IE methods is the “Physics by Inquiry” model developed by the Physics Education Research Group at the University of Washington [12]. In this model, students are exposed to new material through a set of laboratory-based modules. Students develop basic physical concepts from their observations.

The Socratic dialogue inducing (SDI) labs [13], developed by Hake at Indiana University, focus on “guided construction” rather than “guided discovery” or “inquiry”. They emphasize hands-on experience with simple mechanics experiments and facilitate interactive engagement of students with course material. Students are required to discuss a series of conceptual questions with peers and provide their own answers.

1.1.3 Interactive Engagement in Homework

Along with in-class interactive engagement activities, some professors have attempted to provide IE activities as homework. For instance, Holmes and Varriano [14] designed forty homework activities covering the whole introductory physics curriculum. The activities include diagrams, animations, sounds and simulations. They were developed to run in a Microsoft-Dos console. Students can download them and run them on their own computers.

Similarly, Greene [15] has developed a set of web-based activities called Illuminations. The activities cover the Mechanics portion of the Introductory Physics course. Each activity focuses on elaborating a single concept through explorations and explanations. The students in the introductory physics course are encouraged to voluntarily work on Illuminations to supplement their assigned homework.

Even publishers have started providing Interactive problems to supplement books. For instance, Prentice Hall provides some on-line interactive physics problems as a supplementary resource for the textbooks “Physics” (Fifth Edition) and “Physics for Scientists and Engineers” by Giancoli [16]. These problems require students to interact with a simulation.

One popular IE approach adopted by many professors is the Just-In-Time Teaching (JITT) method [17][18]. In this model, students are asked to respond electronically to web-based assignments that are due a few hours before class. The instructor reads the students’ submissions and adjusts the lesson content according to the student performance on the assignment. This allows the instructor to concentrate more

time on the areas that students have found more difficult. Other methods involving the use of IE in delivering homework include the use of practice and drill [8][19].

The effectiveness of these IE methods in delivering homework has been investigated. For instance, Greene compared the effect of both Illuminations and other IE methods on students' learning of mechanics [15]. He found that Force Concept Inventory [20] (FCI) gains of students using Illuminations are higher than the average FCI score gains published in the literature for courses using other IE methods. The results suggest that Illumination can be a valuable means to help students learn important physics concepts through more productive use of their out-of-class study time.

Titus [21] has investigated the effectiveness of assigning multimedia-focused problems. The questions in these problems are focused on videos or simulations. Students need to collect data from the multimedia to solve the problem. He found that multimedia-focused assignments require a more expert-like problem solving strategy; students had more difficulty solving them than solving similar traditional problems. Furthermore, Titus suggests that solid conceptual understanding is necessary to correctly solve multimedia-focused problems.

The effect of drill and practice was investigated by Wong [19] and Thomas [8]. Wong's results indicate that computer drill-and-practice homework helps improve student achievement in mathematics. He also found there is no significant difference in attitude towards mathematics between students who complete the computer drill-and-practice homework and students who complete a regular paper-based homework. Thomas et al. focused on whether or not solving basic skills problems as part of a daily "regimen" can help students improve their performance in physics. His evaluation included three

groups. The first two groups were asked to follow the daily regimen, one using computers and the other using pen and paper. Students in the control group were given a set of book problems each week to complete in their own time. His results indicate that the regimented drill and practice is valuable in enhancing students' long-term ability to solve complex problems, especially to the students at the lower end of the GPA scale. The computer-presented format was more successful than the paper format.

Some researchers have focused on specific elements of the online homework delivery mechanism. Lloyd found that subjects learned more tacit knowledge when provided with animated graphical feedback than with textual feedback, but he found no significant differences between the graphical feedback version and the graphical plus textual feedback version [22]. Other researchers found that instructive animations can help students build connections between words and pictures [23]. Results also show that students successfully extracted incidental information from animated graphics without risk to intentional learning but were also more prone to developing scientific misconceptions [24].

Another experiment focused on students' ability to analyze and interpret motion graphs following laboratory instruction using interactive digital video as well as traditional instructional techniques [25]. The results of this study show that the use of interactive digital video can serve as an effective tool to help students learn more actively. It was also found that using video could enhance student motivation and encourage students to spend more time on a task.

1.2 Purpose of the Research

As stated above, the research literature shows that students acquire some benefits from the use of computer simulations in learning kinematics; the available web-based homework delivery systems are practical but do not take full advantage of the computer's capability of actively engaging students; most of the simulations that are available for teaching physics are designed to illustrate a single topic instead of providing a comprehensive coverage of the topic.

We proposed to develop a comprehensive Web-based tutorial about two-dimensional kinematics. Our goal was that the tutorial promotes active learning through the use of simulation and feedback. We plan then to test the effectiveness of the tutorial as a homework.

Results from this case study will be useful in developing other tutorials and in identifying the factors that might affect the effectiveness of the Web delivered homework.

Chapter II

THE HOMEWORK TUTORIAL

2.1 Topic

As a case study for investigating the effectiveness of the web-based homework, we chose two-dimensional motion for the topic. It is one of the first difficult topics that students learn in introductory physics courses. The difficulty of the topic stems from the fact that students have to learn to separate and later combine the two separate one-dimensional components of the motion. They have difficulty visualizing the different parameters that affect the motion and how the parameters affect it. For example, it is difficult for them to understand that acceleration along the vertical direction does not affect the horizontal component of the velocity [26].

Because of these difficulties, teachers usually resort to demonstrations, drawings and multimedia to help explain the phenomena. There is a wealth of web-based simulations for the topic [17][27][28][29]. The combination of these factors make the topic ideally suited for studying the effectiveness of the web-based homework.

2.2 Previous Work

In addition to the simulations mentioned above some teachers have developed multimedia-enhanced tutorials about two-dimensional motion. The tutorials available online vary in scope and target audience. For example, Tom Henderson's projectile

motion tutorial [8] uses GIF (Graphic image format) animated images to illustrate two-dimensional motion for a high school level physics course. Greene's illumination tutorial [12] about two-dimensional motion uses Java to quiz and illustrate the motion. His illumination tutorials are designed for college level students. M. Casco Associates' tutorial [20] is designed for students and teachers. It used Java to discuss more advanced topics about two-dimensional motion.

2.3 Tutorial Design

Most of the simulations available on the web were developed for use by a teacher for class demonstrations. It is the teachers, not the students, who actually build the connection between the real motion and the physics concept. After teachers demonstrate the simulations in class, students are typically not provide an opportunity to try them out on their own [30]. To help students build their own connections, it is important for them to repeat the process shown by teachers. They need to use the fundamental knowledge described in class to predict and evaluate the factors that affect the motion. A web-based interactive tutorial that students can access at anytime and from anywhere can realize this goal.

Web-based two dimensional homework tutorial (W2dHT) was designed to teach students two dimensional kinematics. Students were asked to manipulate the simulation to get information in order to solve the problems. The simulation can help students get immediate feedback on the parameters they have chosen. After they submit the answers, the tutorial provides additional feedback. This allows students to self-evaluate and to concentrate their effort on the problems where they have the most difficulty or misconceptions.

Both the physics content and the use of technology in facilitating student learning were considered in designing the tutorial. We asked the following questions:

- What are the concepts involved in the topic?
- What are the common student misconceptions in the topic?
- What are the typical problems assigned as homework for this topic?
- What are the difficulties students usually encounter when learning this topic?
- What are the appropriate learning strategies that can help students solve these problems and master the physics concept?
- How can we use the computer to guide students into using these learning strategies?
- How can the computer be used to enhance and improve their learning?

2.3.1 Student Considerations

The University of Minnesota physics education research group has analyzed students' initial academic situation and the desired final state of students in the introductory physics course [31]. They found that most students who enroll in this course are freshmen and sophomores. Usually when they either listen to a lecture, read the textbook or complete a lab experiment, they interpret new information by using their existing knowledge structure. This structure usually includes intuitive conceptions or “misconceptions” that are not easy to change.

For example, in a typical problem “A baseball is thrown with an initial velocity of $(10\hat{i} + 15\hat{j})$ m/s. When the baseball reaches the top of its trajectory, what is its acceleration? Neglect the effect of air resistance.” Many students think that the velocity

and acceleration at the top of the trajectory are zero. They compare this motion to the motion of an object thrown straight upwards. The speed in that case is zero. They fail to see the difference. They reach the wrong conclusion about acceleration because they have difficulty separating the concept of acceleration from speed. They feel little connection between the formulas of two-dimensional motion and the actual motion.

Research also shows that many students tend to study passively—that is, they try to memorize the physics facts and formulas and reproduce them on exams. They have better skills in recollection than in analysis, synthesis and evaluation. Most of them do not really know how to solve problems and they tend to solve problems by recognizing a memorized solution template.

When working on a problem, many students do not know how to connect it to the physics principles involved or to the real world. Even when they identify the related equations, they do not know how to connect the equations to the actual problem or how to reach the correct answer.

Even though students' initial backgrounds vary, the desired final state for all the students from the introductory physics course is essentially the same. The goals are summarized in the following.

- (1) The student can master the fundamental principles of physics.
- (2) The student can master general qualitative and quantitative problem-solving skills.
- (3) The students can evaluate his solutions and correct his mistakes.

Traditionally, professors rely on a combination of lecture, recitation, lab experiments and homework to achieve these goals [32].

2.3.2 Tutorial Content

The web-based interactive homework was designed to cover all parts of the two-dimensional motion topic. The concepts addressed by the tutorial were grouped in three sections and are listed in table 2.1.

Table 2.1 Tutorial Structure

| | |
|-----------|--|
| Section 1 | Vectors and their components (six problems) |
| Section 2 | A. Effect of the various initial parameters (displacement, velocity and acceleration) on two-dimensional motion B. The parameters that affect two-dimensional motion |
| Section 3 | A. Using the initial parameters to predict two dimensional motion parameters. (three problems) B. Solving typical problems in two-dimensional motion (three problems) |

2.3.3 Tutorial Structure

W2dHT is made up of three parts, instruction on the use of a set of tutorial, an introduction to each of the subtopics covered and interactive problem elements.

The instructions explain the use of the tutorial. They include information on how to use the simulation, how to change the motion parameters and how to submit the answers to the question. This instruction is easily accessible throughout the tutorial.

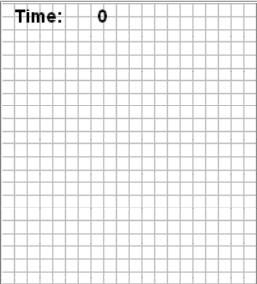
The introduction part includes the basic concepts and formulas addressed in the section that follows. Simulations are provided to help illustrate the basic concepts. The formulas presented in this component are also accessible in the interactive problem component of the tutorial.

The problem part is made up of a set of questions addressing all key points (subtopics). Each question appears on a page that includes the simulation, input boxes, and

control buttons. The input parameters and control buttons depend on the particular question. The simulation, a Java applet, provides an interactive environment enabling students to modify the different parameters involved in the motion (like the angle of the initial velocity, initial x-velocity, initial y-velocity, initial x-displacement, initial y-displacement, x-acceleration and y-acceleration), view the effects of their choices, make any necessary modifications, then answer the question. The questions methodically address the areas that students are known to find difficult.

Two Dimensional Motion

Time: 0



| | |
|---|---|
| A | B |
| | |

| | | |
|--------|-------|--------|
| play | pause | step>> |
| <<step | reset | Help |

Click "play" and examine the change in the three arrows as the pink ball moves, then use information from the graph to complete the table. You may need to use the step buttons to get exact values. The x and y components of the displacement are provided in the table below the graph.

Note: The purple arrow represents the displacement of the ball, the black arrow represents the vertical component of displacement and the red arrow represents the horizontal component of displacement.

d = the magnitude of the displacement. θ = the angle with the x axis of the displacement

pink ball's parameters

| | | | | |
|------------------------------|---|------------------------------|-----|----------------|
| X_0 (m) | 0 | Y_0 (m) | 0 | Symbols |
| V_{x0} (m/s) | 5 | V_{y0} (m/s) | 20 | |
| a_{x0} (m/s ²) | 0 | a_{y0} (m/s ²) | -10 | |

Instruction: complete the fields in the table for the pink ball:

| Time (s) | d (m) | θ (degree)(-90 $\leq\theta\leq$ 90) |
|----------|----------------------|--|
| 1 | <input type="text"/> | <input type="text"/> |
| 2 | <input type="text"/> | <input type="text"/> |
| 4 | <input type="text"/> | <input type="text"/> |

Please note that your solution is saved only when you press the "submit answer" button.

Note that once you press the "submit answer" button, you can not go back to this page

submit answer

Figure 2. 1 A Typical Interactive Problem Component

Figure 2.1 is a typical interactive problem. The simulation is provided at the left-hand side of the page. Instructions are provided to the right of the page. They are

followed by a list of the initial parameters assigned to the simulation and the input boxes used for submitting the answers.

In this case, the student is asked to find the magnitude and direction of the displacement of a ball at times $t=1, 2$ and 4 seconds. To answer the questions, the student needs to know the x and y components of the position vector at the required times. There are two ways to do it. They can use the simulation or use the initial parameters and calculate the required values.

When using the simulation, they can pause it at the prescribed times, read the x and y values from the data-table, make the relevant calculations and answer the questions asked. In addition to providing students with the necessary data, the simulation allows students to visualize the displacement and how it changes in time. The student's answers are checked and feedback is provided after the student clicks the "submit" button. Students may quit the tutorial at this time and continue it at the point the tutorial was stopped the next time they login in.

2.3.4 Tutorial Interactive Components

The interactivity in this tutorial depends on the topic addressed. In all cases, the first level of interaction is with the simulation, and the second level is through feedback. In the following I will describe each of the levels separately.

2.3.4.1 Interactions with the Simulation

In the first three problems of Section 1, students are required to calculate the magnitude and direction of the position, velocity and acceleration vectors at specific times. They have to run the simulation and pause it at the appropriate times and collect

the data of the component of the vectors from the simulation data table. The simulation displays both the vector and its components helping students check and verify their calculations before they submit the answers.

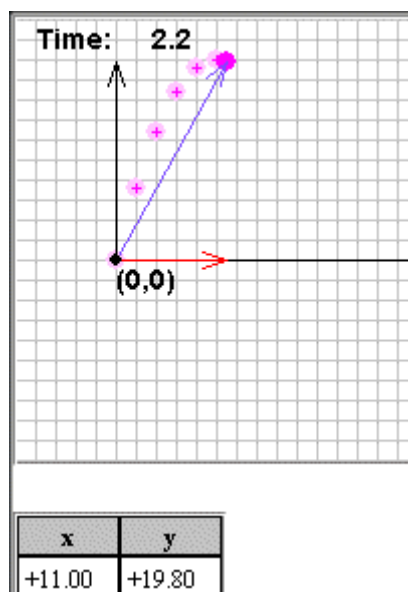


Figure 2. 2 Simulation of a Ball to Providing the Components of the Vector from the Simulation Data Table

Figure 2. 2 illustrates the operation of the simulation. In this case, the simulation is paused at Time=2.2 seconds. The position vector as well as its horizontal and vertical components are shown. In the data table below, the values of each of the components is shown.

Visualizing vectors and their components was meant to help correct student's misconceptions. For an object undergoing projectile motion, students usually have difficulty dissociating the position vector direction from the direction of the velocity. They also have difficulty understanding the changes in velocity and acceleration. Figure 2.3 shows another example of the way visualization is used to help correct student

misconception. In this case, as mentioned before, students have difficulty realizing that the acceleration of a projectile is not zero at the top of the trajectory. The simulation shows them that the acceleration does not change during the whole trajectory.

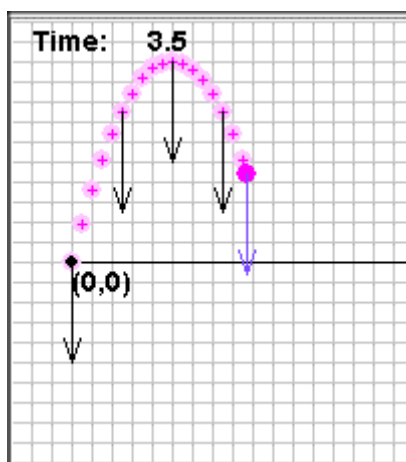


Figure 2. 3 The Simulation Shows That the Acceleration Does Not Change During the Whole Trajectory

In the last three problems of this Section, we reverse the question. We ask students to find the components of displacement, velocity and acceleration as opposed to magnitude and direction. Students are required to collect the data of magnitude and direction of the vectors from the simulation. These exercises are meant to reinforce what was learned in the previous ones. As shown in Figure 2.4, snapshots of the vectors and their components are provided through out the trajectory to help ensure understanding of the behavior of the vectors during the motion.

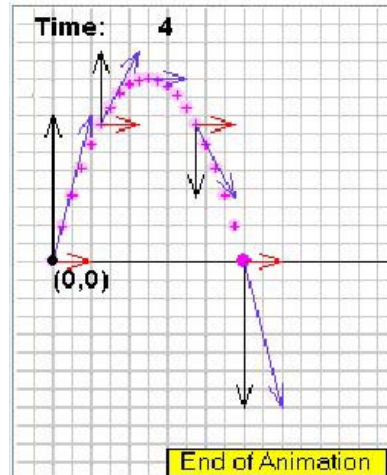


Figure 2. 4 The Simulation for Understanding the Behavior of the Velocity Vector During the Motion

Section 2 of the tutorial focuses on the relationship between the motion of the balls and their initial parameters. At the beginning the instruction illustrates the effect of different a_x (x component of the acceleration) and a_y (y component of the acceleration) combinations on the motion of a ball. The student may change the initial position and the initial velocity of the particle but cannot change a_x and a_y . This is meant to get them to gain a conceptual understanding of how acceleration affects the trajectory. Figure 2.5 shows examples of trajectories due to different accelerations.

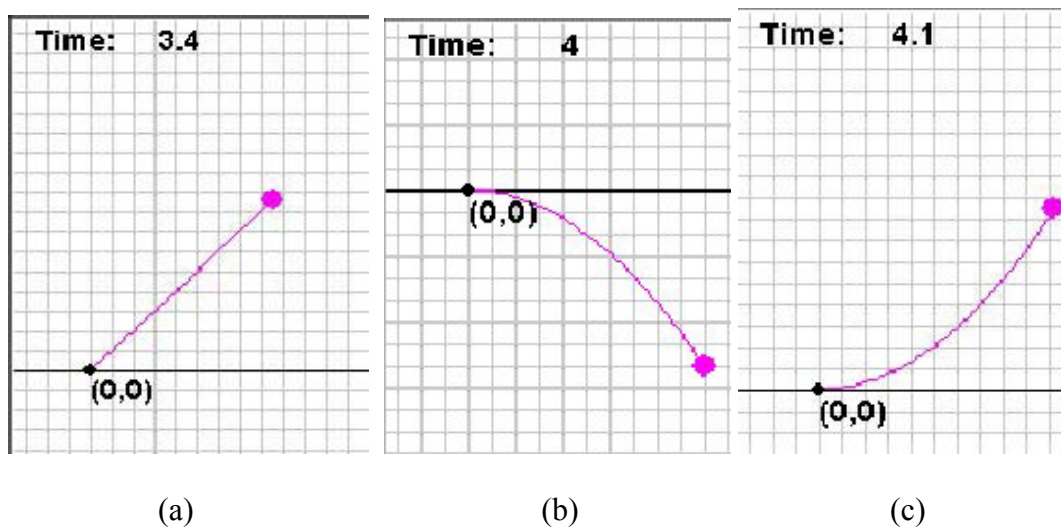


Figure 2. 5 Examples of Trajectories due to Different Accelerations

(a) $a_x=0$ and $a_y=0$; (b) $a_x=0, a_y<0; V_{x0}>0, V_{y0}<0$; (c) $a_x=0, a_y>0$;

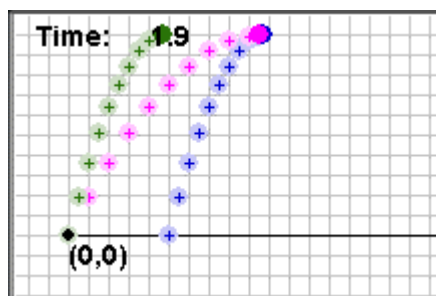


Figure 2. 6 Example of Illustrating the Use of Various Object Trajectories to Deduce Trajectory Parameters

This is followed by problems where the parameters and the corresponding motion of an object are shown, and the student has to alter the parameters so that the object follows another trajectory. An example is shown in Figure 2. 6. The parameters are provided for the ball on the left. The student has to change the parameters of the ball on the left so that it matches the motion to the right. An additional ball is provided to show the initial

motion of the ball. To help eliminate guesswork and to encourage students to analyze the problems, they are allowed to try the simulation a maximum of two times.

Section 2 is finalized with a problem that attempts to summarize what the students have learned so far. They are provided with graphs depicting various trajectories and asked to identify the corresponding initial parameters. They can still use the simulation to test their attempt to match the provided graphs.

Section 3 is made up of four problems that are similar to typical end of the chapter problems. Simulations are still provided to help visualize the problems; however, students cannot run the simulation until they provide an answer to the question.

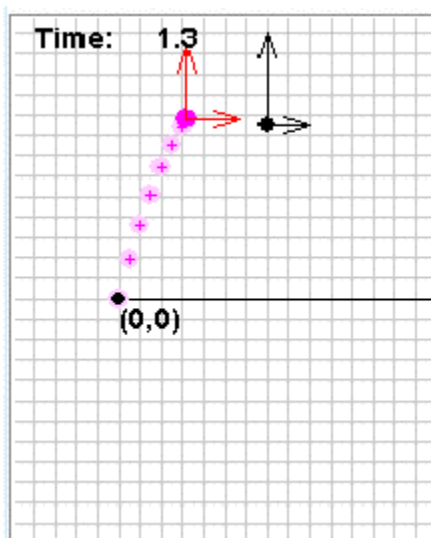


Figure 2. 7 The Simulation that are Provided to Help Visualize the Problems

Figure 2.7 illustrates an example. In this case they are asked to find the components of the velocity at a particular time. They are asked to use the formulas and the initial parameters to find the answer. Once they input answers, they are allowed to run the simulation. The simulation then shows them the components of the velocity

throughout the motion as well as the values they have selected. It is hoped that this will help them reinforce their understanding of the concepts involved. The problems in this section gradually increase in difficulty. Figure 2.8, illustrates a more elaborate use of graphics to help student make a better connection to the “real world”.

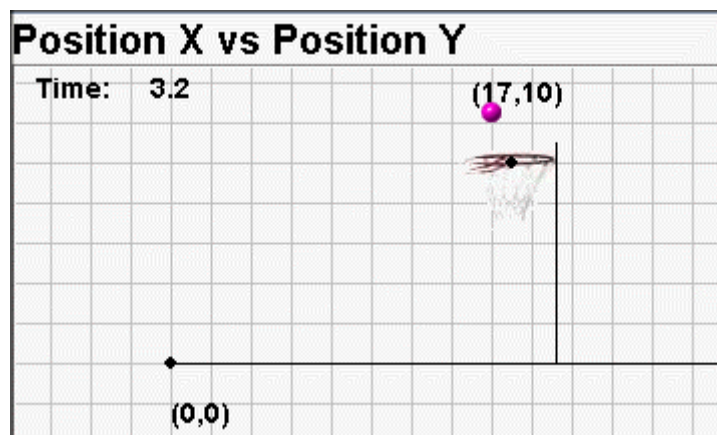


Figure 2. 8 The Simulation Illustrates a More Elaborate Use of Graphics

2.3.4.2 Feedback

The feedback includes a table comparing the student answers to the correct answers. A detailed explanation of the answer is provided below the answers. It gives some explanation specific to this problem and some keynotes on how to solve these types of problems. In most cases, students can go back to the simulation, change the parameters, and verify their answers. In some cases, the interaction includes pop-up messages that are meant to help the student correct problem subparts.

2.4 Programming Details

In designing the tutorial, we relied on several considerations. Some were based on the desire to provide an active learning environment. The others were based on the need to collect as much research data as possible. The goals were:

- Students should be able to interact with the simulation
- Student interaction should be recorded
- Authoring and delivering content should be easy
- The tutorial should provide feedback and form validation
- The tutorial should provide validation of the student input

These goals were accomplished through the use of HTML, Java, JavaScript and Perl programming languages.

2.4.1 Interaction with the Simulation

The simulations provided in each of the problems were based on a scriptable Java applet called “animator” developed by Wolfgang Christian [33]. A typical default setting for the animator applet is shown in Figure 2.9, with the code used to include the applet in the web page shown in Figure 2.10.

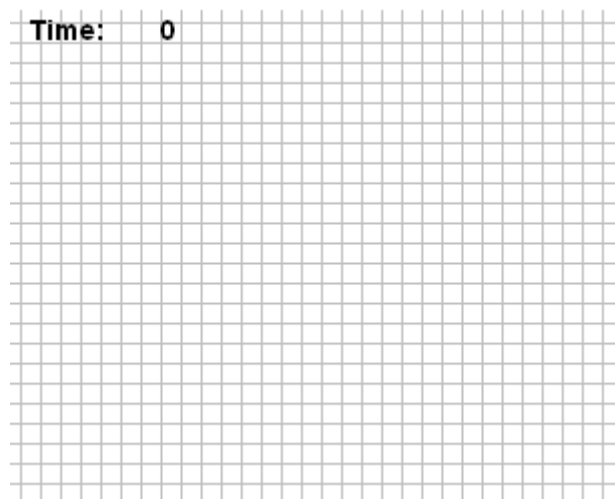


Figure 2. 9 A Typical Default Web Page Setting for the Animator Applet

Table 2.2 The Code Used to Include the Applet in the Web Page

```

<applet code="animator4.Animator.class" codebase="/classes/"
archive="Animator4_.jar,DataGraph4_.jar,DataTable4_.jar,STools4.jar"
name="Animator" id="Animator" width="314" height="256" hspace="0"
vspace="0" align="Middle">
<param name="FPS" value="10">
<param name="ShowControls" value="false">
<param name="dt" value="0.1">
<param name="PixPerUnit" value="10">
<param name="GridUnit" value="1.0">
</applet>
  
```

By using JavaScript, the programmer can add shapes and images, set up equations to control their motion and establish the viewing and interaction components. Figure 2.10 shows a sample simulation. In this case the simulation allows the user to change the parameters of an object (pink ball) that moves in two dimensions. Input boxes are provided in the web page to set the values of the components of initial position (x_0 , y_0), initial velocity (v_{x0} , v_{y0}) and acceleration (a_{x0} , a_{y0}). The JavaScript program used to control the simulation is shown in Table 2.3. When the user presses the “play” button, the “runSimulation” function is invoked. It reads the initial parameters of motion selected by

the user, calculates the x and y positions of the object, and then draws. The process is repeated after the time interval dt set in the applet parameter.

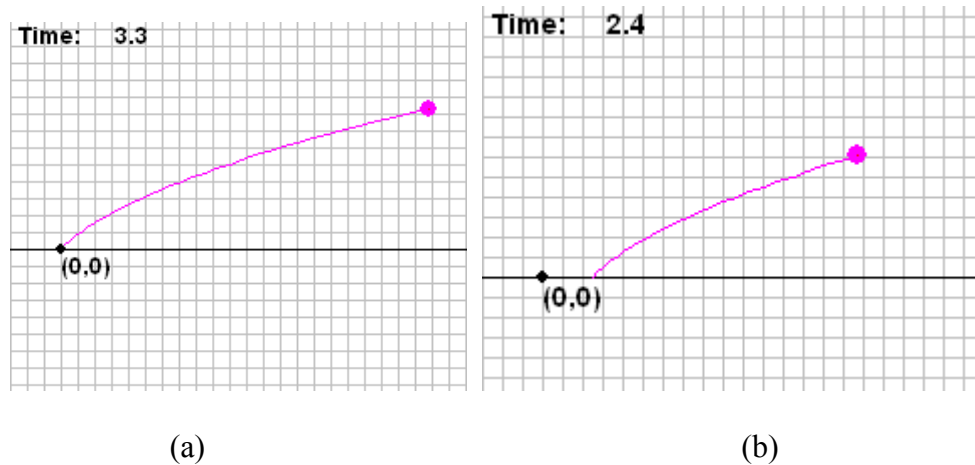


Figure 2. 10 An example Simulation. (a) The Parameters Used for the Motion are $X_0=0\text{m}$, $Y_0=0\text{m}$, $V_{x0}=5\text{m/s}$, $V_{y0}=5\text{ m/s}$, $a_{x0}=5\text{ m/s}^2$, $a_{y0}= 0\text{ m/s}^2$ (b) The Parameters Used for the Motion are $X_0=5\text{m}$, $Y_0=0\text{m}$, $V_{x0}=5\text{m/s}$, $V_{y0}=5\text{ m/s}$, $a_{x0}=5\text{ m/s}^2$, $a_{y0}= 0\text{ m/s}^2$

Table 2.3 The Code of JavaScript for An Example Simulation

```

//JavaScript for pink ball motion

function runSimulation(){

//read initial parameters from web page

x0=document.inputvalues.x0.value;
y0=document.inputvalues.y0.value;
vx0=document.inputvalues.vx0.value;
vy0=document.inputvalues.vy0.value;
ax0=document.inputvalues.ax0.value;
ay0=document.inputvalues.ay0.value;

//Calculate the position of the ball

x_of_t=x0+" "+vx0+"*t"+"+0.5*"+ax0+"*t*t";
y_of_t=y0+" "+vy0+"*t"+"+0.5*"+ay0+"*t*t";

//Setting default viewing parameters for the applet

document.Animator.setDefault();
document.Animator.shiftPixOrigin(-120,-10);
document.Animator.setPixPerUnit(5);
document.Animator.setGridUnit(2);

//Add a dot, a line and the text (0,0) to show the origin.

document.Animator.addCircle(6,"-120","0");
document.Animator.addLine("-170","0","150","0");
document.Animator.addText("(0,0)","-120","-13");

//Add the moving object and set its viewing options

id1=document.Animator.addCircle(10,x_of_t,y_of_t);
document.Animator.setRGB(id1,255,0,255);
document.Animator.setTrail(id1,100000);
document.Animator.setCoordinateOffset(id1,15,0);
document.Animator.setOneShot(0,3.5,"End of Animation");

//Control the applet running cycle

document.Animator.setAutoRefresh(true);
document.Animator.forward();
}

```

2.4.2 Record Students Interaction

JavaScript is also used for recording student interaction with the simulation. We wanted to record each button clicked as well as the time of click and the values used at that time. This was accomplished by setting a hidden variable for each of the buttons and parameters used. A JavaScript function invoked when the page is loaded starts a timer. Each button click or change in parameters invokes another function that reads the time value and adds it to the hidden variable corresponding to it. For example, as shown in Figure 2.11 for V_{x0} if the student chooses 5 the “onchange” event invokes the “q1fnct” function which records the value 5 and the time the student selected it in a hidden variable called “q3val”. If the student changes V_{x0} again, the new value and the time of change are added to the time of change are added to the hidden variable. These data will be sent to server for later retrieval and examination when the student presses the submit button. The data can be useful in examining the student’s progress while working on this problem.

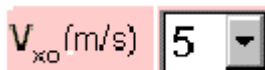


Figure 2. 11 An Example of Recording Change in Parameters

Table 2.4 The Code for Recording Changes in Parameters

```
<!--field used for setting vx0 -- >
<select size="1" name="vx0"
onchange="q1fnct(document.inputvalues.vx0.value) ">
<option value=0>0</option>
<option value=5>5</option>
</select>
```

2.4.3 Providing the Content

Each of the questions in the tutorial was made up of four files having the same name but different extensions. The question text along with any associated scripts, simulations, and form elements were written in a file with the extension “que”. The file can be generated with an HTML editor like Microsoft FrontPage. The text in this file is used to generate the question page as well as part of the feedback page.

The second file included the feedback grid that is used to tell the student whether or not their answer is correct. The extension for this file was “ans”. Because of the special code embedded with the text of the file, it has to be edited with a text editor.

The third file contained the text of the detailed explanation of the answer. It was generated by a HTML editor and given the extension “hp”. The text in this file was displayed in the feedback page.

The last file included the answer values for the question. It was generated by a text editor, and its extension is “dat”.

2.4.4 Providing Feedback and Form Validation and Interaction

We used JavaScript to validate the data and to control the interaction with the simulation. The functionality used can be characterized as one of three uses. The first use was to control the number of times the student is allowed to run the simulation. An alert box appeared whenever the student exceeded the maximum number of attempts and interaction with the simulation disabled. The second use was to check whether or not the student has completed a calculation before attempting to run the simulation. The third use was to provide immediate feedback for more complicated multipart problems. Students

are allowed to figure out the answer to the various subparts before completing the whole problem.

2.4.5 Tutorial Engine

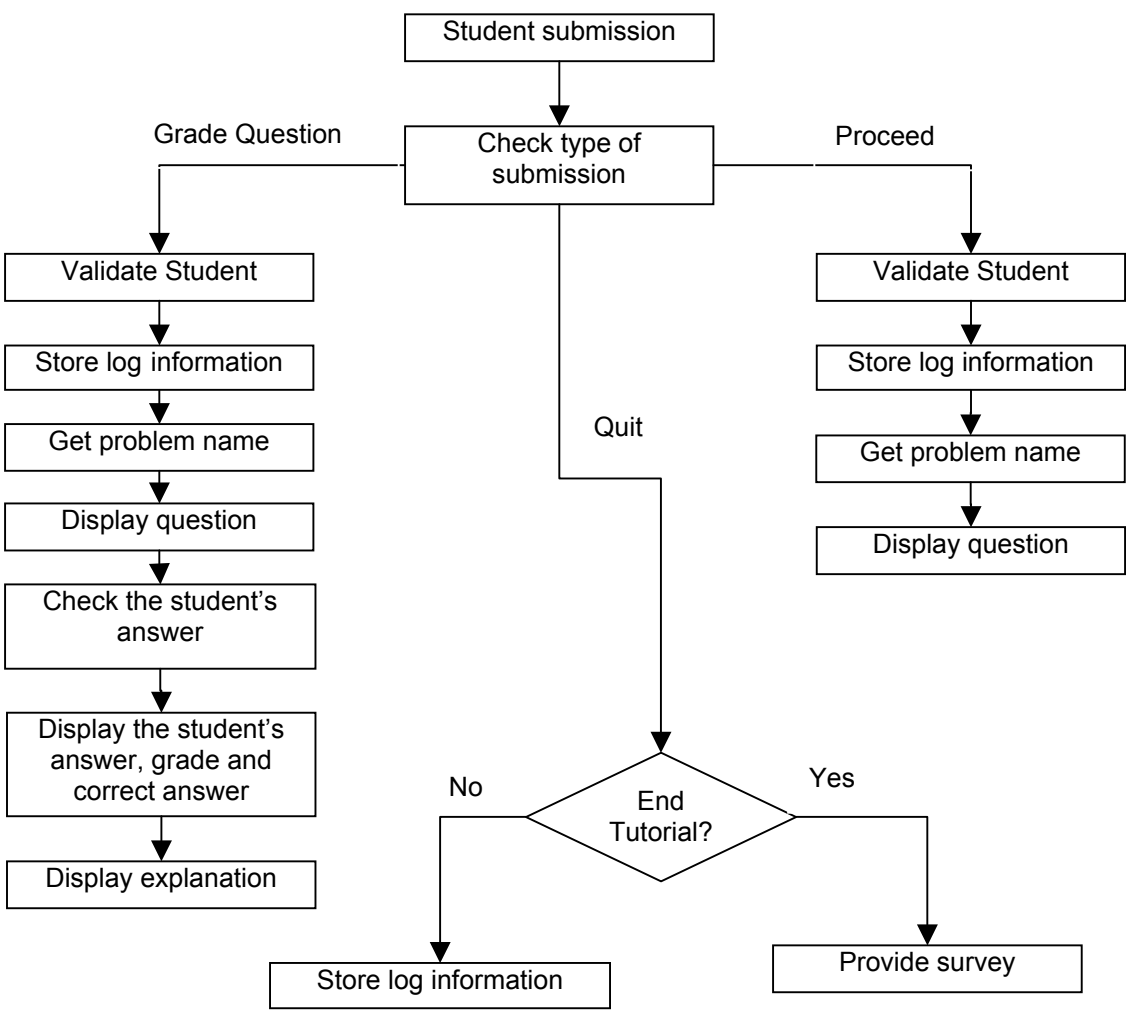


Figure 2. 12 Tutorial Delivery System

The inner workings of the tutorial are based on a CGI program written in Perl. The first time the CGI program is invoked a login screen appears. After login in every time the user presses a submit button the process followed is illustrated in Figure 2. 12.

The tutorial provides three types of submit buttons named “submit”, “proceed” and “quit”. The CGI procedure followed depends on the name of the button used. A separate subroutine is used to accomplish each of the functions listed in the Figure 2. 12.

Chapter III

EVALUATION OF THE TUTORIAL

3.1 Purpose of the Evaluation

To help understand how learning occurs through web-delivered media, this study specifically focused on students' performance and attitude when they completed an interactive web-based homework.

The study evaluated the possibility of using an interactive web-based homework model as an alternative to the regular homework assignment. The analysis was based on two experiments each involving two treatments. The following is a breakdown of the topics addressed.

Item a. What is the difference in performance on the posttest between students who completed interactive web-based homework and those who completed homework in the traditional format?

Item b. What is the student's attitude towards the interactive web-based homework?

Item c. Do students with different academic backgrounds perform differently under different homework environments?

3.2 Methodology

The subjects of the study were students enrolled in four sections of Physics I (PH2213) at Mississippi State University during the Spring 2001 semester. Participants were all volunteers. Three of the four sections were taught by Dr. Pelaez and the fourth was taught by Dr. Mzoughi.

In Experiment 1 students were drawn from Dr. Pelaez's sections. As an incentive for completing the experiment students were allowed to drop their lowest quiz grade. Quizzes and homework were worth 30% of their overall class grades. A total of 129 students agreed to participate, although only 65 completed the experiment. The purpose of the experiment was to study the difference in the performance between interactive web-based homework and the regular homework done by students in an environment and at a time of their own choice.

In Experiment 2, students were from Dr. Mzoughi's section. As an incentive for completing the experiment students were allowed to add five points to their lowest test grade. A total of 25 students agreed to participate but only 19 completed the experiment. The purpose of the experiment was to study the difference in the performance and attitude of students completing the interactive web-based homework and students completing the regular homework in a computer lab via the web with immediate feedback.

For both experiments the topic of the homework was two-dimensional kinematics. In particular, the purpose was to get the students to understand the following points:

- The relationship between vectors and their components;

- The relationship between the displacement, velocity and acceleration vectors and their components;
- The relationship between displacement, velocity, and acceleration of an object;
- The effect of the initial position, velocity, acceleration on the motion of an object.

The posttest addressed all four topics.

Approval for conducting the experiment was secured from the Mississippi State University institutional review board (IRB) for the protection of human subjects in research in January 2001.

3.2.1 Experiment 1

The study was performed after Dr. Pelaez completed the lecture on two-dimensional kinematics and after the students were given a test on the subject.

The researcher was allowed to go to class, describe the project and ask for volunteers. The volunteers were asked to complete a consent form and a demographic survey (Appendices 1). The demographic survey asked students about their academic background, gender, major, GPA, ACT, SAT, etc.

Since most of Dr. Pelaez's students had completed the Force Concept Inventory (FCI) during the first week of classes, we elected to use that test score to help ensure a balanced distribution between the two treatments. In the following class period the researcher provided the subjects with their assignment and asked them to complete the homework in two weeks.

The experimental group (Interactive) in this experiment was asked to complete a computer-based simulation with immediate feedback. They worked on the tutorial on their own time and used the computer facilities available to them. At the end of the assignment, the subjects were asked to complete a short computer-based survey about their attitude and impression of the tutorial.

The control group (Regular) was asked to complete a regular homework using pencil and paper. The problems chosen for the regular homework were selected from the textbook that was used for the course. These problems did not cover the problems that the professor had previously assigned to the whole class.

On the due date, access to the Web-based homework by the experimental group (Interactive) was disabled and the regular homework was collected from the control group (Regular). The regular homework was corrected and returned to students along with detailed correct answers during the following class period. A 20-minute posttest was given during class one week after the due date.

The posttest included 9 problems and was completed by pen and paper. Seven of the problems were chosen from questions used in Physics I tests during previous semesters. The other two questions were chosen from the Test Item file: Physics Principles with Applications (Rex Joyner), Chapter 3 “Kinematics in Two or Three Dimensions; Vectors”.

The posttest problems were checked by the professors involved in the study to ensure that the posttest provided a fair analysis for students learning of two-dimensional kinematics, that it addressed the topics of the study, and that it was not biased.

3.2.2 Experiment 2

The study was performed after Dr. Mzoughi completed the two-dimensional kinematics lecture, and after students were given a test on the subject. Dr. Mzoughi described the project to the class and asked for volunteers. The volunteers were asked to send emails to Dr. Mzoughi to confirm their interest. Volunteers were then asked to meet at the library's instructional lab facilities.

The treatments consisted of two versions of web-based homework with instant feedback. The experimental group (Interactive in lab) worked with the interactive version used in Experiment 1. The control group was provided with the same homework problems as the control group of Experiment 1. However, in this case, the control group (Regular with computer) was provided with the assignment via computer and was provided with immediate feedback.

As in Experiment 1, subjects were divided into two groups based on their FCI score. After they came into the library computer lab, they completed the consent form and the demographic survey. The consent form and the demographic survey were identical to the ones used in Experiment 1. The subjects were then asked to complete the assignment via computer. At the end, the subjects filled out a short computer-based survey about their attitude and impressions of the tutorial. This survey was identical to the one given to the experimental group (Interactive) of Experiment 1. After completing the assignment, subjects took the posttest using pen and paper. The posttest was identical to the one used in Experiment 1.

3.2.3 Statistical Analysis

In this research, we used two sets of data, which came from two completely separate samples. We compared the data by using a t-test¹ for independent measurement and the analysis of covariance (ANCOVA)² method at a 0.05 level of significance.

3.3 *Data Analysis*

The data analysis addressed each of the three evaluation items listed in section

Item a. What is the difference in performance of posttests between students who completed interactive web-based homework and those who completed homework in the traditional format?

Although our original statistical design was balanced, some students failed to complete all or parts of the experiment and that resulted in an imbalance in the number of students participating in each treatment and in a possible imbalance in their background. Therefore, an ANCOVA analysis was used. This model can be used in an unbalanced design and it provides an analysis of covariance, and a regression analysis for each response variable.

In this case, we used the Force Concept Inventory scores (FCI) as a covariate. The fixed factor was the treatment the students were subject to (TREATMNT). The results were as follows:

¹ “The t statistic is used to test hypotheses about an unknown population mean μ in situations where the value of standard deviation σ is unknown.” “ $t = (\text{sample mean (from the data)} - \text{population mean (hypothesized from } H_0)) / (\text{estimated standard error})$ ” Gravetter, F.J. & Wallnau, L.B. (1997) *Statistical for the behavioral sciences: A first course for students of psychology and education* (4th ed.), pp289 & pp293

² ANOCA is an extension of analysis of variance in which group differences (or independent variable) are assessed after dependent variable scores are adjusted for differences associated with one or more covariates, variables that are measured before the dependent variable and are correlated with dependent variable.

Table 3.1 Mean of the Posttest Score by Two Type of Homework in Experiment 1

| | Interactive | | | Regular | | |
|----------|-------------|-----------|----------|----------|-----------|----------|
| | <u>M</u> | <u>SD</u> | <u>n</u> | <u>M</u> | <u>SD</u> | <u>n</u> |
| Posttest | 4.44 | 2.37 | 41 | 4.63 | 2.70 | 24 |
| FCI | 12.54 | 6.23 | 41 | 11.71 | 6.61 | 24 |

Note. Regular= students who completed the regular homework at home; Interactive= students who completed the interactive web-based homework at home; M=Mean³; SD=standard deviation⁴; n=number of subject.

The mean posttest score for students who completed “Regular” was 4.63, with a standard deviation of 2.70 and for “Interactive” was 4.44, with a standard deviation of 2.37. The ANCOVA results were that the posttest score for both treatments was not significantly different ($p=0.316$)⁵. However, the FCI scores had a significant effect on the posttest scores, $p<0.05$.

The same analysis was performed for Experiment 2. The results were as follows.

³ “The mean for a distribution is the sum of the scores divided by the number of scores.” Gravetter, F.J. & Wallnau, L.B. (1997) *Statistical for the behavioral sciences: A first course for students of psychology and education* (4th ed.), pp78.

⁴ “Sample standard deviation is the square root of the variance.” Gravetter, F.J. & Wallnau, L.B. (1997) *Statistical for the behavioral sciences: A first course for students of psychology and education* (4th ed.), pp126.

⁵ “The probability of committing a Type I error (less than 5%)” Gravetter, F.J. & Wallnau, L.B. (1997) *Statistical for the behavioral sciences: A first course for students of psychology and education* (4th ed.), pp297.

Table 3.2 Mean of the posttest score by two type of homework in Experiment 2

| | Interactive | | | Regular | | |
|----------|-------------|-----------|----------|----------|-----------|----------|
| | <u>M</u> | <u>SD</u> | <u>n</u> | <u>M</u> | <u>SD</u> | <u>n</u> |
| Posttest | 5.90 | 2.51 | 10 | 6.00 | 1.87 | 9 |
| FCI | 12.8 | 6.00 | 10 | 11.1 | 4.82 | 9 |

Note. Regular with computer: students completed the regular Web-based homework on a computer at a scheduled time in a computer laboratory setting; Interactive in lab: students completed the interactive Web-based homework on a computer at a scheduled time in a computer laboratory setting.

The mean posttest score for “Regular with computer” was 6.00 and for “Interactive in lab” was 5.90. The difference in the posttest scores of the two treatments was not significant, $F=0.446$, $p>0.05$ (F is F -ratio⁶). The FCI score had a significant effect on the posttest score, $F=11.551$, $p<0.05$.

The Coefficient alpha reliability⁷ of the posttest has been found to be 0.75 for $N=65$. The value is sufficiently high that the posttest is reliable and can be used for group assessment.

Summary:

The results from both experiments can be summarized as follows:

⁶ “ F = variance (differences) between sample means/variance (differences) expected by chance (error)”

Gravetter, F.J. & Wallnau, L.B.(1997)Statistical for the behavioral sciences: A first course for students of psychology and education(4th ed.),pp400.

⁷ “Reliability refers to the consistency of the measurement obtained for the same persons upon repeated testing.” Coefficient alpha “yields results similar to KR-20 when used with dichotomous items.” It “can be used for test with various item formats”

Ruth Ravid, (1994) Practical statistics for educators, pp241&pp247

The effects of the regular homework and interactive web-based homework on the posttest scores were not significantly different even when the FCI cores were used as covariate.

Item b. What is the student's attitude towards the interactive web-based homework?

To get information on students' attitudes, a five-question survey was given at the end of the tutorial. Only students who completed the online version of the tutorial participated in the survey. They had to answer the survey on-line using a scale from 1 to 5. For questions 1 through 4 the high scores indicated positive attitude toward the tutorial. For question 5, low scores indicated positive attitude toward the tutorial. The questions were:

- Question 1 (Interest): How interesting is the tutorial?
- Question 2 (Comprehension): Rate your comprehension of the tutorial:
- Question 3 (Learn): I think this is a good way to learn
- Question 4 (Like): I would like instruction in my courses like this
- Question 5 (Focusing): I had trouble focusing my attention during this instruction

Students in two different treatments completed the survey. "Regular with computer": students completed the regular Web-based homework on a computer at a scheduled time in a computer laboratory setting. "Interactive in lab": students completed the interactive Web-based homework on a computer at a scheduled time in a computer laboratory setting.

An independent t-test was used to analyze the data gathered in Experiment 2. The results are summarized in Table 3.3. A significant difference is obtained only for item “interest”, $p < 0.05$. This indicates that the students thought that their learning environment was more interesting relative to their peers in the regular condition.

Table 3.3 Attitudes Differences between Students who did Regular Homework with Computer and Those who did Interactive Web-based in Experiment 2

| Question | Regular with computer | | | Interactive in lab | | | t |
|---------------|-----------------------|------|---|--------------------|------|----|--------|
| | M | SD | n | M | SD | n | |
| Interest | 2.56 | .53 | 9 | 4.00 | .94 | 10 | -4.05* |
| Comprehension | 3.00 | .71 | 9 | 3.10 | .99 | 10 | -0.25 |
| Learn | 2.78 | 1.2 | 9 | 3.70 | .95 | 10 | -1.84 |
| Like | 2.56 | 1.33 | 9 | 3.00 | .82 | 10 | -0.89 |
| Focusing | 2.44 | .88 | 9 | 3.30 | 1.16 | 10 | 0.09 |

Note. Interest=Question 1 in survey; Comprehension = Question 2 in survey; Learn = Question 3 in survey; Like = Question 4 in survey; Focusing = Question 5 in survey; Regular with computer= students completed the regular Web-based homework on a computer at a scheduled time in a computer laboratory setting; Interactive in lab=students completed the interactive Web-based homework on a computer at a scheduled time in a computer laboratory setting.

* $p < 0.05$

The ANCOVA was also used to analyze the data obtained in Experiment 2. The fixed factor in the analysis was treatment (TREATMNT) and the covariate was FCI scores. The result shows that the FCI scores have no significant effect on the attitudes.

We compared the time different groups spent on the homework. The students in treatment “Interactive in lab” spent more time ($M=81.38$, $SD=8.16$, $n=10$) on homework than students in treatment “Regular with computer” ($M=45.85$, $SD=14.92$, $n=9$). This difference is not statistically significant, $p > 0.05$.

In summary, in the survey about attitude, treatment “Interactive in lab” had higher means than treatment “Regular with computer” on question 2,3,4,5, but the difference was not significant. There was significant difference in question 1 between the two treatments. Students who completed the interactive web-based homework spent more time than those who completed the regular web-based homework.

Item c. Do students with different academic backgrounds perform better under some type of homework environment?

To analyze the students’ academic background, data collected were grade point average (GPA), standardized test scores (ACT/SAT), FCI scores and pretest scores. Since the ACT and SAT were alternatives for students, we used the following formula [34] to convert ACT scores to their equivalent SAT scores:

$$\text{SAT Total} = 317.431528 + 33.09935 * (\text{ACT Composite}).$$

The results are summarized in Table 3.4:

Table 3.4 Mean of some Factors of Students' Academic Background in Experiment 1

| Background | Regular | | | Interactive | | |
|------------|----------|-----------|----------|-------------|-----------|----------|
| | <u>M</u> | <u>SD</u> | <u>n</u> | <u>M</u> | <u>SD</u> | <u>n</u> |
| SATT1 | 1218 | 158 | 21 | 1203 | 128 | 39 |
| PRETEST | 1.54 | .78 | 24 | 1.37 | .77 | 41 |
| FCI | 11.71 | 6.61 | 24 | 12.54 | 6.23 | 41 |
| GPA | 3.18 | .58 | 21 | 3.24 | .56 | 40 |

Note. SATT1= total SAT scores; FCI = the FCI scores; PRETEST= the score in the two-dimensional part of test 1; GPA = grade point average; Interactive = students completed the interactive web-based homework at home; Regular = students completed the regular homework at home.

41 students completed the interactive web-based homework at home and 24 students completed the general homework at home. There were no significant differences of students' academic background on the two different treatments.

3.3.1 Additional Investigation

After analyzing the data from Experiments 1 and 2 we decided to make the following investigation. What is the effect of the environment on the student attitude when they complete the interactive web-based homework?

In this case we compare data from students who completed the interactive web-based homework at home (Experiment 1) with data from students who completed the interactive web-based homework on a computer at a scheduled time in a computer laboratory setting (Experiment 2).

Table 3.5 Attitudes Differences between Students who did Interactive Web-based Homework at Home and Those who did Interactive Web-based Homework at Lab

| Question | Interactive | | | Interactive in lab | | | t |
|---------------|-------------|-----------|----------|--------------------|-----------|----------|--------|
| | <u>M</u> | <u>SD</u> | <u>n</u> | <u>M</u> | <u>SD</u> | <u>n</u> | |
| Interest | 3.06 | 1.12 | 34 | 4.00 | .95 | 10 | -2.61* |
| Comprehension | 2.68 | 1.25 | 34 | 3.10 | .99 | 10 | -1.11 |
| Learn | 2.86 | 1.26 | 34 | 3.70 | .95 | 10 | -2.29* |
| Like | 2.91 | 1.29 | 34 | 3.00 | .82 | 10 | -0.26 |
| Focusing | 2.94 | 1.11 | 34 | 3.30 | 1.16 | 10 | 0.87 |

Note. Interactive in lab = students completed the interactive web-based homework on a computer at a scheduled time in a computer laboratory setting; Interactive = students completed the interactive web-based homework at home; Interest = Question 1 in survey; Comprehension = Question 2 in survey; Learn = Question 3 in survey; Like = Question 4 in survey; Focusing = Question 5 in survey.

* $p < 0.05$

The independent t-test statistics method was again used. The results are as given in table 3.5. The data show that treatment “Interactive” had lower mean value in all five questions than treatment “Interactive in lab”. Significant differences are obtained only for item “Interest” and “Learn” between the two treatments, $p < 0.05$.

We also studied the time spent completing the interactive web-based homework at home vs. in the computer laboratory. The students who completed it at home spent more time ($\underline{M}=118.79$, $\underline{SD}=60.32$, $n=34$) on homework than students who completed it at computer lab ($\underline{M}=81.38$, $\underline{SD}=8.16$, $n=10$). Nevertheless the difference was not significant, $t=1.949$, $p=0.058$.

In summary, in the survey about attitude, treatment “Interactive in lab” had higher means than treatment “Interactive” on question 2,4,5, but the difference was not significant. There was significant difference in question 1 and 3 between the two

treatments. Furthermore students spent less time doing the same homework in the computer lab than at home.

A caution remains, however, the results of the additional analysis are not scientifically valid. Instead, they were done only to probe possible future investigations.

Chapter IV

DISCUSSION AND CONCLUSION

4.1 Discussion

We measured the students' achievement, attitudes and academic background in Experiment 1 and Experiment 2. The results are as follows.

4.1.1 Achievement

The results of this preliminary study suggest that the interactive web-based homework may be used as an alternative to the general homework.

This conclusion is supported by the statistical result from Experiment 1 and 2 comparing the posttest scores of students who completed the web-based homework and general homework. Scores were not significantly different. An ANCOVA analysis of the scores using the Force Concept Inventory (FCI) as a covariate has not shown a significant difference.

4.1.2 Attitude

The data collected in Experiment 2 suggests the experimental group thought that the tutorial was more “interesting” than the control group. This is in spite of the fact that students spent more time on the interactive web-based homework than on the general web-based homework.

An interesting by-product result from the experiment is the participation level of students. Of the students who agreed to participate in the experiment only 55% of the

control group students in Experiment 1 completed the homework versus 86% for the experiment group students. This is despite the technical difficulties that the experimental group students might have encountered. This preliminary data should be investigated further.

In summary, the interactive web-based homework can be considered as an alternative to the general homework in large-scale course. It strengthened positive attitudes among the students and it seemed to encourage more students to complete it than the general homework.

4.2 Future Research

Initially the designer was hoping that the interactive tutorial provided an enhanced learning environment over the general homework. The experimental results and student comments provided a glimpse on what might have caused this shortcoming. For instance, many students complained about the instructions. They claimed that in many instances the instructions were difficult to follow. They also suggested the addition of more worked out examples. Some students also talked about the technical difficulties they have encountered. Both problems can be easily fixed by providing clear direction for the tutorial content and the use of the tutorial. Other problems might be due to the experimental design. For instance, due to time limitations and liability issues, the experiment was performed after the students completed a test on the material covered. This may mean that some students had reached their thresholds of learning [35] before participating in the experiment. This effect might be reduced by conducting the experiment during the later part of the semesters when students start to forget some of the material covered.

On the other hand some items that might be worth investigating are the effect of the technology and feedback provided on student learning. The results show that students spend a significantly longer amount of time working on the tutorial. It is not clear from the present data how much of the time was spent trying to manipulate the simulation or deal with technical difficulties rather than exploring the physics. A more thorough analysis of the log files might help us answer this question. The log analysis might also help us determine if the students are taking full advantage of the interactivity during the feedback.

Finally, this study did not investigate the effect of the tutorial on students' problem solving abilities. Many studies suggest that improved conceptual understanding improves the problem solving ability [36]. Nevertheless, if tutorials were to be used to replace homework, a thorough investigation is necessary.

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APPENDIX 1
QUESTIONNAIRE

Computer user ID _____

Do not mark in this space

1. Please circle the information that best describes you:

Year in School: Freshman Sophomore Junior Senior

Sex: Male Female

2. What is your major? _____

3. What is your current overall GPA? _____

4. What was your ACT math score? _____

What was your ACT total? _____

What was your SAT math score? _____

What was your SAT total? _____

Other standardized test and score? _____

5. Have you taken physics in high school?

6. Have you taken trigonometry in high school?

7. Have you taken calculus in high school?

8. Have you taken other physics or math classes while in high school? Yes No

If you answered yes, please list the classes, including course number and name, the grade you received, when you were enrolled in the class (eg. , presently, 1 year ago), and indicate whether you took the course at MSU or at another university.

| Course Number | Course Name | Grade | How long ago? | Where was it taught? |
|---------------|-------------|-------|---------------|----------------------|
| | | | | |

APPENDIX 2
POST TUTORIAL EXERCISES

Problem 1. If a ball is thrown with a velocity of 25 m/s at an angle of 37 degrees above the horizontal, what are the horizontal component and the vertical component of the initial velocity? (use $g=10 \text{ m/s}^2$)

- | | |
|------------------|-------------------|
| [1] 25m/s, 15m/s | [2] 25m/s, 25m/s |
| [3] 15m/s, 15m/s | [4] 15m/s, 20m/s |
| [5] 18m/s, 20m/s | [6] 20m/s, 15m/s |
| [7] 20m/s, 20m/s | [8] 18m/s, 15m/s |
| [9] 20m/s, 18m/s | [10] 25m/s, 18m/s |

Problem 2. Consider a projectile under the influence of gravity with no air resistance. Assume that the angle at which the projectile leaves the origin is 35° about the horizontal. When it is at its highest point, what is the direction of its velocity vector? (use $g=10 \text{ m/s}^2$)

- [1] vertical and up
- [2] vertical and down
- [3] no direction because it's zero
- [4] horizontal and forward
- [5] horizontal and backward
- [6] at 35° about the horizontal
- [7] at 35° below the horizontal
- [8] at 55° about the horizontal
- [9] at 55° below the horizontal
- [10] at 145° relative to the horizontal

Problem 3. A ball thrown horizontally from a point 24m above the ground, strikes the ground after traveling horizontally a distance of 18m. With what speed was it thrown? (use $g=10 \text{ m/s}^2$)

- | | |
|--------------|---------------|
| [1] 6.10m/s | [2] 7.40m/s |
| [3] 8.22m/s | [4] 8.96m/s |
| [5] 8.96m/s | [6] 5.10m/s |
| [7] 7.80m/s | [8] 9.22m/s |
| [9] 10.00m/s | [10] 18.96m/s |

Problem 4. A football is kicked with an initial vertical velocity component $V_y=10.0 \text{ m/s}$ and an initial horizontal velocity component $V_x=17.3 \text{ m/s}$. Neglecting air resistance (i.e. the only acceleration is the vertical acceleration due to gravity, $g=10.0 \text{ m/s}^2$), how long (in seconds) will the ball stay in the air before hitting the ground? (use $g=10 \text{ m/s}^2$)

- | | |
|----------|-----------|
| [1] 2.00 | [2] 17.3 |
| [3] 1.00 | [4] 4.00 |
| [5] 20.4 | [6] 34.6 |
| [7] 32.3 | [8] 35.3 |
| [9] 38.3 | [10] 20.0 |

Problem 5. Two objects are released from the same height h above the level ground at the same time. Object A is just dropped with zero initial velocity and object B is given a horizontal velocity of 15m/s. Assuming $g=10 \text{ m/s}^2$ and $h=30\text{m}$, which statement is correct?

- [1] Object A reaches the ground 2s before object B
- [2] Object B reaches the ground 2s before object A
- [3] Object A reaches the ground $\sqrt{2}$ s before object B
- [4] Object B reaches the ground $\sqrt{2}$ s before object A
- [5] Object A reaches the ground 3s before object B

- [6] Object B reaches the ground 3s before object A
 [7] Object A reaches the ground $\sqrt{3}$ s before object B
 [8] Object B reaches the ground $\sqrt{3}$ s before object A
 [9] Object B and object A reach the ground at the same time
 [10] None of these

Problem 6. A pilot drops a bomb from a plane flying horizontally at a constant velocity of 20m/s at an altitude of 1,000m. When the bomb hits the ground; what is the horizontal location of the plane relative to the bomb? (use $g=10 \text{ m/s}^2$)

- [1] be 20,000m before the bomb
 [2] be 20,000m in front of the bomb
 [3] be 50m before the bomb
 [4] be 50m in front of the bomb
 [5] be 200m before the bomb
 [6] be 200m in front of the bomb
 [7] be 1000m behind the bomb
 [8] same as the bomb
 [9] be 1000m in front of the bomb
 [10] none of these

Problem 7. In a field goal attempt a football is kicked so that its initial velocity is $(20\hat{i} + 12\hat{j}) \text{ m/s}$ where \hat{i} is parallel to the ground and \hat{j} is up. When the football was at its highest point, what were the magnitudes of its velocity (in m/s) and acceleration (in m/s^2), respectively? (use $g=10 \text{ m/s}^2$)

- [1] 0, 10.0
 [2] 17,0
 [3] 17,10.0
 [4] 20,0
 [5] 20, 10.0
 [6] 21, 0
 [7] 21, 10.0
 [8] 23,0
 [9] 23, 10.0
 [10] 0,0

Problem 8. In a field goal attempt a football is kicked so that its initial velocity is $(20\hat{i} + 12\hat{j}) \text{ m/s}$ where \hat{i} is parallel to the ground and \hat{j} is up. 1.5 seconds after it was kicked, what was the direction of the velocity of the football? (use $g=10 \text{ m/s}^2$)

- [1] 6.7° above horizontal
 [2] 6.7° below horizontal
 [c] 8.5° above horizontal
 [4] 8.5° below horizontal
 [5] 9.0° above horizontal
 [6] 9.0° below horizontal
 [7] 15° above horizontal
 [8] 15° below horizontal
 [9] 30° above horizontal
 [10] 30° below horizontal

Problem 9. A soccer ball is kicked with a velocity of 35m/s at an angle of 45degrees above the horizontal. What is the vertical component of its acceleration as it travels along its trajectory? (Neglect air friction, use $g=10 \text{ m/s}^2$ and use up as positive)

- [1] 1.0m/s^2
 [2] -35.0m/s^2
 [3] 10.0m/s^2
 [4] 45.0m/s^2
 [5] -10.0m/s^2
 [6] 5.0m/s^2
 [7] -24.7m/s^2
 [8] 24.7m/s^2
 [9] 35.0m/s^2
 [10] 17.5m/s^2

APPENDIX 3
IRB APPROVAL FORMS



Mississippi State
UNIVERSITY

Regulatory Compliance Office
Institutional Review Board
P.O. Box 6156
Mississippi State, MS 39762
662-325-3994

January 8, 2001

Jie Liang
PO Box 5167
Mississippi State, MS 39762-5167

Re: IRB Docket #00-450—A Study of Web-based Computer Aided Instruction of 2
Dimensional Motion.

Dear Jie:

The above referenced project has been approved via administrative review for the project period of January 4, 2001 through June 15, 2001, in accordance with 45 CFR 46.101.B1. Please find enclosed your approval form for the above referenced IRB application.

The IRB reserves the right, at anytime during the project period, to observe you and the additional researchers on this project.

Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact me at 325-3994 or at tarwood@spa.msstate.edu.

Sincerely yours,

A handwritten signature in cursive script that reads "Tracy S. Arwood".

Tracy S. Arwood
Regulatory Compliance Administrator

TSA/jm

Enclosures

cc: ✓ Taha Mzoughi
File

**INSTITUTIONAL REVIEW BOARD APPROVAL FORM
FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH
MISSISSIPPI STATE UNIVERSITY**

STATEMENT OF BOARD: _____ **IRB DOCKET#** 00-450

This is to certify that the research proposal entitled: A study of web-based computer aided instruction of 2 dimensional motion

and submitted by: **Name:** Jie Liang

Department: Physics & Astronomy

Name of Advisor: Taha Mzoughi

to Sponsored Programs Administration for consideration has been reviewed by the Regulatory Compliance Officer or the IRB and approved with respect to the study of human subjects as appropriately protecting the rights and welfare of the individuals involved, employing appropriate methods of securing informed consent from these individuals and not involving undue risk in the light of potential benefits to be derived therefrom.

Administrative Approval Date: 1/4/01 **Expiration Date:** 6/15/01

(A) Contingent upon receipt of _____

(B) All necessary documents were received

Expedited Approval Date: _____ **Expiration Date:** _____

(A) Contingent upon receipt of _____

(B) All necessary documents were received

Full Board Approval Date: _____ **Expiration Date:** _____

(A) Contingent upon receipt of _____

(B) All necessary documents were received
Tracy S. Arwood MSU Regulatory Compliance Officer 1/8/01
Date

Institutional Review Board Member _____ **Date** _____