

# Learning Basic Sciences Via The Web: A Simulation-Based Approach

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تعلم المقررات العلمية الأساسية  
من خلال قواعد الويب بمنحني المحاكاة

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### الملخص

يتطرق البحث إلى معالجة تطبيقات قواعد الويب ذات الاتصال المباشر باستخدام طرق المحاكاة، ويبين طريقة تطوير وبناء مجموعة من أدوات قواعد الويب المتكاملة والتي بدورها ستمكّن عرض المقررات العلمية الأساسية؛ ومن هذه الأدوات الفلاش والجافا. ويتناول البحث في مرحلته الأولى تقديم المفاهيم الأساسية لمحاكاة الاتصال المباشر، ثم يتناول في مرحلة اللاحقة عرضاً للنظام المقترح. ويتدرج البحث إلى وصف البيئة التوزيعية لحوسبة الكيانات والتي قد تم اعتمادها في الدراسة، ومن ضمنها أساليب العرض المتخصص، والتي يمكن الوصول إليها عن بعد باستخدام الخدمات التي يقدمها نظام الويب.

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## *Abstract*

This paper addresses the implementation of an on-line web based simulation experiment. It explicates the development and integration of web-based tools to support introductory science courses and demonstrates how tools like Flash and Java can be used in developing online simulation courses.

The paper first provides a basic overview of the on-line simulation approach. Next, it illustrates the system that was considered in this study. The paper then describes the distributed object-computing environment that has been employed in the study, including the specialized displays that can be accessed by a remote participant using the services of the Web.

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## Introduction

The communication revolution in the 20<sup>th</sup> Century has modified, and is continuing to radically transform modern societies by increasing social displacements and space-time compression of information transmission. Yet our academic models and educational practices still rely to a large degree on practices and models that belong to an age in which print and the oral word were the dominant media of communication.

During the second half of the 20<sup>th</sup> Century there was a significant and ongoing evolution in educational technology in that the technology became not only widespread, but also more sophisticated in the possibility it provided for creating, collecting, processing and disseminating information. Educational technology is not, and never will be transformative on its own. It requires the assistance of educators who integrate technology into the curriculum, align it with student learning goals, and use it for engaged learning projects. Therefore, professional development for teachers becomes the key issue in using technology to improve the quality of learning in the educational institutions.

Many years ago schools and books were the only source of education but today there are so many sources available such as audio, videotapes, a variety of computer software and the Internet. The computer plays a very important role not just as a tool to improve learning but also for instructional purposes. Unfortunately as time has progressed so has the emphasis placed on educational computing changed? These changes of emphasis are the result of many changing factors some of which would be the increased power and capabilities of hardware and software, increased availability of the technology in schools and advances in other technologies such as computing innovations. This is basically

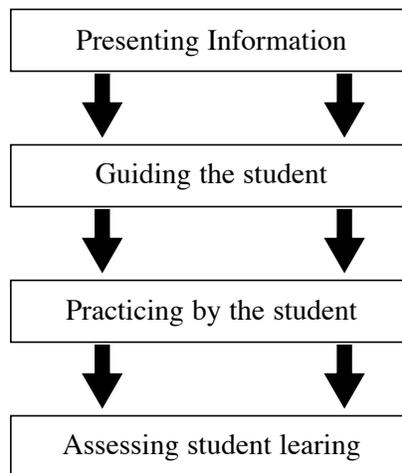
because most of the software present today does not comply with the characteristics of computer-based instructions (CBI).

In this article we will discuss the characteristics of simulation based CBI's. We will focus on the importance of online simulation approaches, which can be employed to facilitate the presentation of difficult courses to learners with the help of application tools such as Flash and Java.

Firstly, we will discuss in general the importance of computer-based instructions and the five methodologies used to provide a strong base for understanding and developing good computer based instruction. Secondly, we will focus on discussing one methodology: Simulation based CBI. Lastly, we will emphasize the main theme of this article which is web based simulation for teaching basic sciences.

### Computer Based Instructions

Computer based instructions can also be termed as an enrichment to the standard courseware (Allis & Trollip, 1991). It is defined as the use of a computer in the delivery of instruction. Momentarily instruction has been accentuated rather than education in general; therefore we use the term CBI. As CBI is based on an expository model of instruction, there are 4 phases that should be followed (illustrated in figure 1) in order for this instruction to be effective.



**Figure 1. Phases of CBI**

The following paragraphs will briefly describe each of these phases

**Presenting Information:** This phase is instructor-centered. In order to teach something new, the instructor must first present the information. This may take a number of forms. For verbal or pictorial information, an instructor may present rules and examples, show pictures, or provide other nonverbal information. To teach skills such as doing a long division, the instructor will probably model the skill so that student can imitate them.

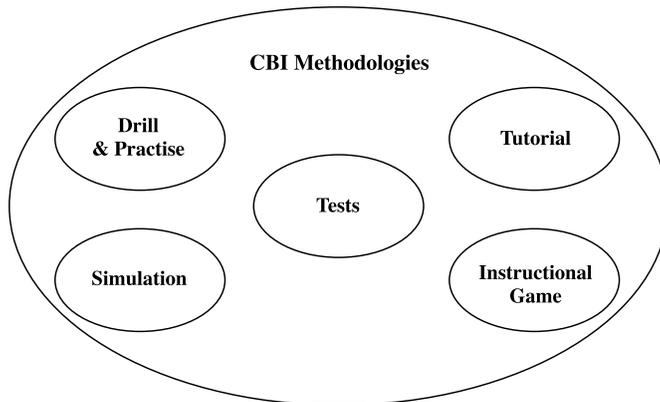
**Guiding the student:** This phase is more interactive. After the learner receives the information he/she has to be guided on how to use the instruction and should be examined to see if he/she perceived the lesson.

**Practicing by the student:** When the student is able to demonstrate the material, that is not the end of the instructional process. The student must be able to perform quickly even under conditions of distraction at times, with few or no errors. Therefore, repeated practice is often required for the student to retain the information and to become fluent with it.

**Assessing student learning:** Students learning must be assessed, usually with tests, which are an important part of the instructional process. Tests provide information about the level of learning, quality of teaching, and future instructional needs.

## CBI Methodologies

In order to acquire a strong base for understanding and developing good computer based instruction, certain methodologies (illustrated in figure 2) are practiced.



**Figure 2. CBI Methodologies**

**Drill and Practice** involves exercises that are designed to increase fluency in a new skill or body of knowledge or to refresh an existing skill or body of knowledge. This approach assumes that the learners have previously been introduced to the content.

**Tutorial** is a form of CBI in which the computer assumes the role of a tutor who is introducing the content, providing practice and assessing learning. Tutorials are used to introduce new content to learners in much the same manner that a human teacher might.

**Simulation** provides a simplified presentation of a real situation, phenomenon, or process. It provides the opportunity for students to apply knowledge in a realistic format but without the time, expense or risk associated with the real thing. Simulation can be utilized for any of the four instructional phases.

**Instructional Games** are powerful tools, which provide practice in an entertaining way and are always preceded by the first two phases.

**Tests** satisfy the fourth phase of instruction by evaluating the student knowledge and how much s/he has learned.

The main theme of this research study concerns concentrating on the development of a web-based simulation course for teaching basic sciences.

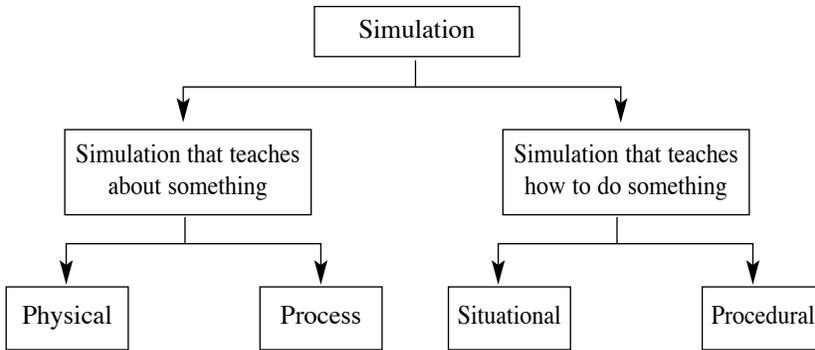
### **CBI and Simulation**

In a simulation, the learner is exposed to a realistic scenario and is required to make decisions, which subsequently have a direct impact on how the scenario unfolds. Simulations allow learners to explore the results of actions that they would be unable to take in the real world due to danger, cost or inconvenience. Computer-based technology offers a particularly effective medium for the development of simulations. Simulation provides students with good presentation of information as well as good interaction with the world as if they were in real situations. It simplifies the logical model by removing details from the physical model.

There are two types of simulations:

- A Simulation that teaches about something
- A Simulation that teaches how to do something.

Each of these in turn, may be divided to other sub-types as shown in Figure 3.



*Figure 3. Types of Simulation*

However, this classification is not standard, not every real simulation must fall under one of these categories. Rather, a simulation may be a combination of two or more of them.

**Physical Simulation** is the type of simulation the student can acquire a clearer concept of the physical object or the phenomenon that is presented to him /her on the screen.

**Process Simulation** is concerned with simulating objects or phenomena that are not visible to the student or the user, for example, the process of food digestion in the human body.

**Procedural Simulation** is the type of simulation to teach the sequence of a procedure. Procedural simulations usually contain objects simulated physically. Procedural simulation teaches the student sets of rules.

**Situational simulation** concerns with attitudes and behaviors of people in different situations. Situational simulation teaches the student the effects of different approaches to a situation.

### **Advantages of Simulation**

Advantages of simulation may be discussed in two different stages as follows:

#### **Advantages of Simulation over reality**

- Providing experiences not readily available in real situations.

- Simulations can be more controlled than reality
- Cost effective
- Ability to enhance safety
- Reducing complexity of real world objects
- Being available at any time
- Being repeatable any number of times
- Facilitating initial learning

### **Advantages of Simulation versus other types of instructional methodologies**

- **Motivation:** Simulation enhances motivation by making the student being an active part of the instructional process rather than a passive part.
- **Transfer of Learning:** By simulation skills and knowledge learned in one situation apply in other situations. With the help of simulation what has been learned by a simulator can be easily transferred to the real world.
- **Efficiency:** Efficiency means that transfer of learning can be gained in less time. However, this is true with simulation compared with other instructional methodologies like lectures and textbooks.

### **The World Wide Web and Simulation**

The web has evolved tremendously over the past decade with applications in education (Ellis & Jensen, 1997), marketing, financial services, supply chain management, and logistics. Web technology is also having a significant impact on the field of computer simulation. Web-based simulation reflects more of a technology transfer than a robust theoretical development; rapid advances are achieved through practical applications.

There are several advantages for web-based simulations which:

- can be run on a local or remote computer.

- is platform-independent and operating-system-independent.
- can be accessed through the Internet or Intranet using any web browser, such as Netscape or Internet Explorer
- can provide excellent graphical animation and interface that needs very minimum maintenance

The integration of the web with the field of simulation should provide lots of ideas for how simulation is to change. With the web being the driver of much of today's software technologies, simulations need to study how we can embed simulation "documents" in browsers and how new distributed web-based simulations are to be designed.

Web-based simulation is quickly emerging as an area of significant interest for both simulation researchers and simulation practitioners. This interest in web-based simulation is a natural outgrowth of the proliferation of the World-Wide Web and its attendant technologies, e.g. HTML, HTTP, CGI, etc., and the surging popularity of, and reliance upon, computer simulation as a problem solving and decision support system tools.

Currently, the researchers in the field of web-based simulation are interested in dealing with topics such as methodologies for web-based model development, collaborative model development over the Internet, Java-based modeling and simulation, distributed modeling and simulation using web technologies, and new applications. However, in this research study, we are going to demonstrate how web-based simulation concepts can be employed in teaching a basic science course.

### **Software used in developing web-based courses**

One of the most misunderstood aspects of developing web-based presentations or courseware is that it requires more than just the main hypermedia-authoring program like Dreamweaver or Microsoft FrontPage. Other software tools are needed to construct the graphics, sounds, and animations that are the ingredients of a good courseware program. As a minimum, there are 6 major types of programs (listed in table 1) and several utilities that should be learned in order to be able to develop a good courseware program.

| Basic Groups of Software  |
|---|
| Authoring Software<br>Graphics Software<br>Drawing Software<br>Video Editing Sound Editing Software<br>Modeling/Animation/Rendering Software<br>Sound Software<br>Data creation Software<br>Simulation software |

Table 1: Basic Groups of Software

Software used in designing courseware is listed in Table 2 along with comments about each program. More than basic 6 programs are described since some capabilities overlap.

Table 2: Software used in developing courseware

| Basic Software used in developing courseware |   |   |   |
|--|---|---|---|
| Software                                     | Example   | Software                                      | Example   |
| <b>Authoring</b>                             | Director<br>Browser<br>Authorware               | <b>Graphics</b>                               | Photoshop<br>PhotoStyler<br>Painter<br>Xres<br>Plug-ins (Eye Candy,<br>Kai Power Tools)   |
| <b>Drawing</b>                               | Illustrator<br>Freehand<br>Canvas<br>Corel Draw | <b>Modeling/<br/>Animation<br/>/Rendering</b> | Studio 3D Max<br>Infini-D<br>Extreme 3D<br>Strata 3D Studio<br>Day Dream Designer<br>Electric Image<br>SoftImage<br>Alias/Wavefront |
| <b>Video Editing</b>                         | Premiere<br>After Effects<br>VideoShop          | <b>Sound Editing</b>                          | Sound Forge (Win)<br>Sound Edit (Mac)   |

| Basic Software used in developing courseware |  |  |   |
|--|--|--|---|
| Software                                     | Example  | Software                               | Example   |
| <b>Data creation</b>                         | Finite Element programs<br>Computational Fluid Dynamics<br>Mathematics<br>Excel Spreadsheet<br>MathCad<br>MathLab<br>Working Model | <b>Simulations and web-Based tools</b> | Director<br>Java<br>JavaScript<br>Programming Language (C, Basic, etc.)<br>HTML editor (Dreamweaver)<br>VRML editor (VRCreator)<br>Streaming Video (NetShow, Quicktime)<br>Vector Animation (Flash)<br>Movie Compression (Premiere) |

The following paragraphs will briefly describe major software used in developing web-based courseware.

### Macromedia Director

This is a general purpose-authoring tool that has grown from a rather simple 2D-animation program to a commercial level multimedia-authoring program (Gross, Elley, & Toker, 2000). The latest release, version 8, has a number of very good features to let you tie web material into your production. It is easy to use for simple tasks but takes time to learn all of its many capabilities. It is very powerful and is currently the program of choice for most commercial multimedia developers. The program is organized along a timeline (or score) and you place objects (called cast members) on the screen (called a stage) at different times. It is very good at 2D animation since it is based on a timeline, but it does not have any 3D motion or animation capabilities (new version of Director started to include 3D features). Built into Director is a good basic paint program, but it is not a complete bit-graphic program like Photoshop. One of the great advantages in using Director is its cross-platform capabilities. Any source file developed in the Windows version will play in the Mac version and vice versa. It even accepts

both Video for Windows and QuickTime movies. If the students (or instructors) plan to distribute their work, this cross-platform capability is very important.

### **PhotoShop**

This is currently the standard paint and photo-editing program for graphic artists (Sing, et al., 1999). Its strong point is modifying existing images such as photographs that have been scanned into the computer (other programs such as Fractal Painter are more useful for creating paint graphics). It can do about anything to an image (e.g., a photograph) that you can dream up (after using this program you will never believe a photograph again). It is not a good drawing program, and you will be frustrated if you try to use it to make technical pictures.

### **Premier**

This is the current standard program for digital video editing. This program lets you import videos, animations, sound tracks, pictures, graphs, etc. and combine them together to make a single linear video or QuickTime movie. There are hundreds of special effects such as fades, transparencies, overlays, moving TVs, etc. This program is a basic video production studio where you can create about 75% of what commercial broadcast studios can do. Direct output to a VCR is also possible, but without high end VCR equipment, you will only get about 60% of the quality you see on TV. (Sorry, you will not be able to make TV commercials with the software!) With all this video power, you must be careful to watch the size of the video files, which can quickly become VERY large (hundreds of megabytes).

### **Flash**

This is a new program that lets you produce nice 2D animations for the Internet. It uses vector-drawing techniques to keep the file size small. It has fast become the professional standard for producing high-impact on the web for advanced animation techniques. It is fun to use and the output files are very small. The new features in Flash provide enhanced capabilities for creating artwork, streamlining your workflow, and creating interactivity, including expanded capabilities for creating interactivity with ActionScript (Franklin & Maker, 2002).

## Java Scripts

Many times Java (Lemy & Perkins, 1996) is just too much for what is needed for your web site. Java Script (Sing, et al., 1999) is a simple scripting language that is embedded right in the HTML page. The language is simple to learn, but is still powerful. It can allow you to do some very clever things, like monitoring user clicks, storing data in variables, opening up custom browser windows, and do technical calculations. This session will introduce how it is used with HTML and what can be done with it.

## A Prototype System

Having described some of the major software used in developing a web-based simulation, in this section we are going to demonstrate the capabilities of one of these courses in designing a simple prototype system to teach a basic science course.

The prototype system will demonstrate how to construct a vector-based animation using Flash. The drawing commands are easy to learn so you will be spending more time on the special functions that Flash has to offer. The final file will be placed on web pages. Currently, Flash is the only program that does vector animations on the web, but there will surely be more to come. One downside to flash is the need to have a plug-in driver to run the animation.

In order to develop a courseware you should learn the following concepts of flash:

1. Basic drawing in Flash
2. Buttons and navigation
3. Moving and rotating objects
4. Saving files and publishing them on web pages
5. Plug-ins for browser
6. Converting Flash to a Java Applet

### **Pendulum Animation**

The prototype system demonstrates how to develop a Vector based animation of the Pendulum as shown in figures 4 and 5.

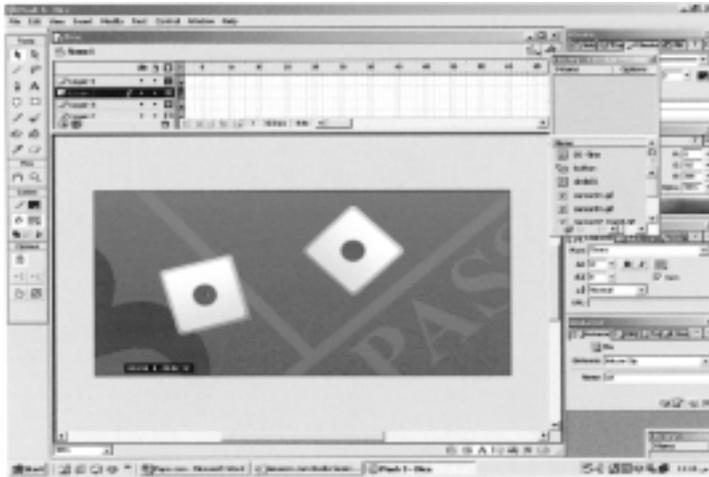


Figure 4. A Simple Flash Screen

The animation will include the following:

- Swinging Pendulum
- Ball
- Rope
- Sin Graph (import from Freehand
- Animation of graph
- Add sound
- Embedded into Web page

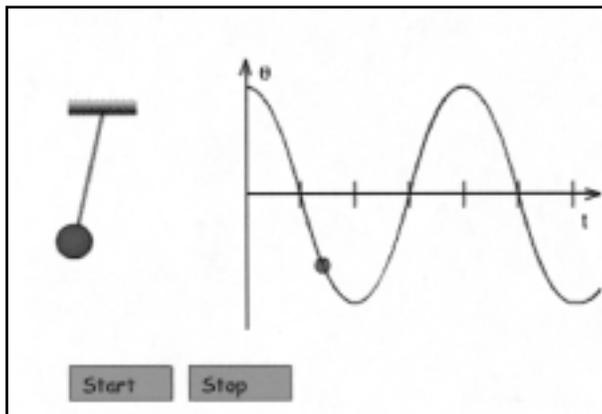


Figure 5. a Vector based animation of the Pendulum

## Conclusion

This study implies and advocates the importance of the new role technology portrays in the revolutionizing needs of the educational arena. The procession towards a better and more interactive way of teaching Basic Sciences via the Web leads us to a conclusion that the more traditional modes of teaching are to be reviewed and modified for effective learning.

A major improvement and point of convenience is the grasping and understanding of complex courses, which need more than books and educators. It also allows for flexibility in the delivery of material in terms of the number of participants, the timing of the teaching and the learning process. Moreover, it requires new skills and competencies.

The particular design of the Web based simulation reported in this paper, however, was not meant to replace the traditional means of teaching and learning but to enhance them so that collaboration and contextual learning could be added rather than completely displace the traditional forms. Consequently, as the role of controllers in the simulation indicates, the authority of lecturers and tutors was not completely replaced but rather advanced by their role as facilitators.

The lesson learned from the experience of the online simulation is that while our older academic models for teaching have significant limitations, using software tools via the web, if designed with an eye to enhancing older forms rather than eliminating them, can create a teaching environment that is fun and highly productive for students.

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