

THE EXPLORATION OF SOLAR SYSTEM USING MULTIMEDIA TECHNOLOGY

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Abstract. *One of the most rapidly changing and exciting areas of education today is the development of computer-based educational materials or courseware. The purpose of the project is to develop an educational courseware prototype that presents a vivid multimedia adventure unfolding the splendor of the Solar System. The targeted end-users of the courseware will be high-school classes, as well as non-science majors in introductory astronomy classes. The courseware enables students to discover the facts and phenomena of the Solar System through an archive of text, graphics, audio, videos, 2D and 3D animations. The courseware also includes self-assessment components can be integrated to provide the student with immediate feedback. The development of courseware is important in offering enhanced exploration and educational enjoyment of the Solar System and beyond. It provides a comprehensive self-learning and interactive material to the students via multimedia technology.*

1. Introduction

Computer graphics and multimedia technologies are becoming widely used in educational applications because they facilitate non-linear, self-learning environments that particularly suited to abstract concepts and technical information. Maurer & Scherbakov [14] suggest that multimedia can improve the overall learning experience for a student while Gibbons (1990) states that interactive multimedia enables students to link data, information and ideas intuitively; the ability for the student to make such connections is critical to learning [4]. This paper unfolds some of our experiences in developing a CD-ROM based multimedia courseware called 'SolMiC'. SolMiC is an interactive courseware prototype that delivers basic scientific knowledge of the Solar System through a vast archive of photographs, scientific facts, text, graphics, and animations. The courseware contents are designed based on the Form 3 Science syllabus and other related resources that are suitable for secondary education. The targeted users are the middle school audiences as well as non-science majors in introductory level Astronomy classes.

1.1 The Motivation

The motivation behind the development of the courseware is to reform the traditional 'talk and chalk' teaching approach and to increase the student's comprehension rate in the selected topic. Currently, the teachers are using the textbooks as the material of teaching to deliver the Solar System bodies to the students. Since there are many scientific concepts in Solar System topic, thus it is not easy to clearly explain most problems by using words and static pictures from the textbooks. Therefore, we proposed the development of multimedia courseware to break this limitation. Multimedia makes it feasible to produce courseware that enables the teachers to deliver the lesson in a more intuitionist and attractive way. The proposed courseware can enhance student's understanding by supporting the theoretical facts with components such as graphics, video, audio, and animations. The tutorial module includes three levels of assessment: Beginner, Intermediate, and Advanced, to determine how much the students learned after the lesson. Besides, the degree of interaction, and control of the courseware provides a flexible learning environment that enable students to learn at their own pace.

2. Related Work

Interactive multi-media learning can be delivered as a simulation of a virtual world via CD-ROM, a Web-delivered tutorial, or a simple interactive lesson downloaded from the Web [2]. This section covers some of the examples of courseware development on the Solar System that come in many forms.

NASA, the Planetary Data System, and the Data Distribution Laboratory are pleased to provide the educational CD-ROM entitled, 'Welcome to the Planets' [19], consisting of over 200 selected images acquired over approximately 25 years of NASA planetary exploration. Each image is accompanied by information about Solar System bodies and various spacecraft that explored them. The primary intent of this courseware is to provide individuals and teachers with an overview of planetary exploration, at approximately a high school or college level.

The 'Views of the Solar System' [5] by Calvin J. Hamilton is an online website that offers enhanced exploration and educational enjoyment of the solar system and beyond. A full color images, animated clips and informative text are designed with powerful navigational tools to assist the reader to explore contents in the website.

The 'Astronomy Village: Investigating the Solar System' [16] is an educational product aimed at astronomy instructional materials for middle school audiences. This multimedia development, funded by the NSF, will be suitable for curriculum supplement, presentations, and public outreach in Earth and planetary science. Students using this curriculum will solve problems in a rich environment that includes images, hands on labs, simulations, presentations, articles, and web pages. The research questions will be presented using multiple working hypothesis formats.

3. The Constructivist Influence on Interactive Multimedia Design

When it comes to science education, asking students just to memorize facts and concepts prevents them from experiencing authentic science and gives them a false impression of how science is actually practiced. In addition to being unrealistic, it is also an authoritarian way of teaching science [9]. The current understanding and recommended approach towards science education is the Constructivist approach. Constructivism has done a service to science education for example Astronomy: by alerting teachers to the function of prior learning and extant concepts in the process of learning new material, by stressing the importance of understanding as a goal of science instruction, by fostering pupil engagement in lessons, and other such progressive matters [15]. Research shows that pupils frequently come to their lessons having constructed their own explanations for many of the easily observed astronomical events, and that these children's notions or 'alternative frameworks' are at variance with the accepted view [3][6]. The following are basic tenets of constructivism that will be implemented within the multimedia courseware [Kevin]:

- a. *Knowledge is constructed from and shaped by experience.*
- b. *Students must take an active role and assume responsibility for their learning.*
- c. *Learning is a collaborative process and students create their own meaning from obtaining multiple perspectives.*
- d. *Learning should occur in a realistic setting.*
- e. *Learners should choose their own path through content and activities.*
- f. *Content should be presented holistically, not broken into separate smaller tasks.*

With computer and multimedia technologies, a constructivist approach to training is easier than ever before. The interactive exercises are designed to help introduce or reinforce main lesson concepts, to test knowledge, to provide a game-like environment within which to learn, or to offer experiments and simulations to actually conduct scientific investigations. CD-ROMs provide a rich media context for simulations. Realism is obtained with the use of audio, video, animations and virtual workspaces. The integration of multimedia components like text, narration, graphics (animations and videos permits the presentation of complex concepts. With computer simulations, abstract models are presented visually. A visual environment that can be manipulated and controlled offers learners a tool with which they can intuitively experience formal, abstract concepts [17]. Use of a discussion board enables students to create a virtual scientific community. The global nature of the Internet also means that communication between learners is without the barriers of time and place. Using navigation tools and hyperlinks within courseware resources, allows learners to journey on a process of discovery.

4. Instructional System Design Model

The courseware is developed based on the ADDIE instructional system design model, which revolves around the Analysis, Design, Development, Implementation and Evaluation components.

a. The Analyze Phase

In the initial phase, requirements planning and analysis were carried out to identify the goals and objectives of the courseware development, the target users and their current capabilities, relevant course materials, delivery options and the timeline for courseware completion. The targeted end-users of the courseware will be high-school classes, as well as any individual who are interested in gaining fundamental knowledge in Astronomy. The final output will be a series of executable files *.EXE that will be delivered on CD.

b. The Design Phase

The following five main steps in the design phase were conducted. They include identifying the outcomes of the instruction, applying identified instructional strategies according to the content type, generating storyboards, preparing narrative scripts and collecting the needed materials.

c. *The Development Phase*

The Development phase is the process of authoring and producing the materials needed to meet the objectives of the SolMiC multimedia courseware. Generating multimedia content comprises of activities such as designing the user interface, converting printed text into electronic form, editing images and sound effects, generating 2D and 3D animations, narrating edited text and finally integrating all the components into the a package. The output of the development phase is a courseware prototype that shows what the final courseware will look like when it is complete.

d. *The Implementation Phase*

In the Implementation phase, the final multimedia courseware is developed based on needs and errors discovered while utilizing a prototype courseware with members of the target audience – teachers and students.

e. *The Testing Phase*

In the testing phase, there are two modes of evaluation involved. The Formative evaluation that is carried out while the educational package is actually being developed, while the Summative evaluation carried out once the development phase of the education package has been completed [10].

5. A Closer Look at SolMiC Courseware

This section discusses the design and development of the courseware in-depth. The courseware structure, material design and development guidelines followed in the SolMiC development will be explained.

5.1 Development Environment

Since selection of suitable multimedia tools is vital for courseware development, it is appropriate to briefly mention the tools used to design and develop the courseware prototype. The entire development of SolMiC prototype is established on Windows platform. Macromedia’s Authorware served as authoring tool while Adobe’s Photoshop was used for image editing. Macromedia’s Flash is used to create two-dimensional animations whereas 3D Studio Max is used to model three-dimensional animation that explain the subject materials through video simulations. Sound Forge digital audio editor was used to edit and record narrative audio and sound effects.

5.2 Courseware Structure

The Figure 1 shows the flow of the contents in the SolMiC courseware. The Main Menu contains all the navigation icons which link it to every other component’s screen in the courseware. The course materials are classified into five components: *Concepts*, *Assessment*, *Additional Resources* and *Support* component.

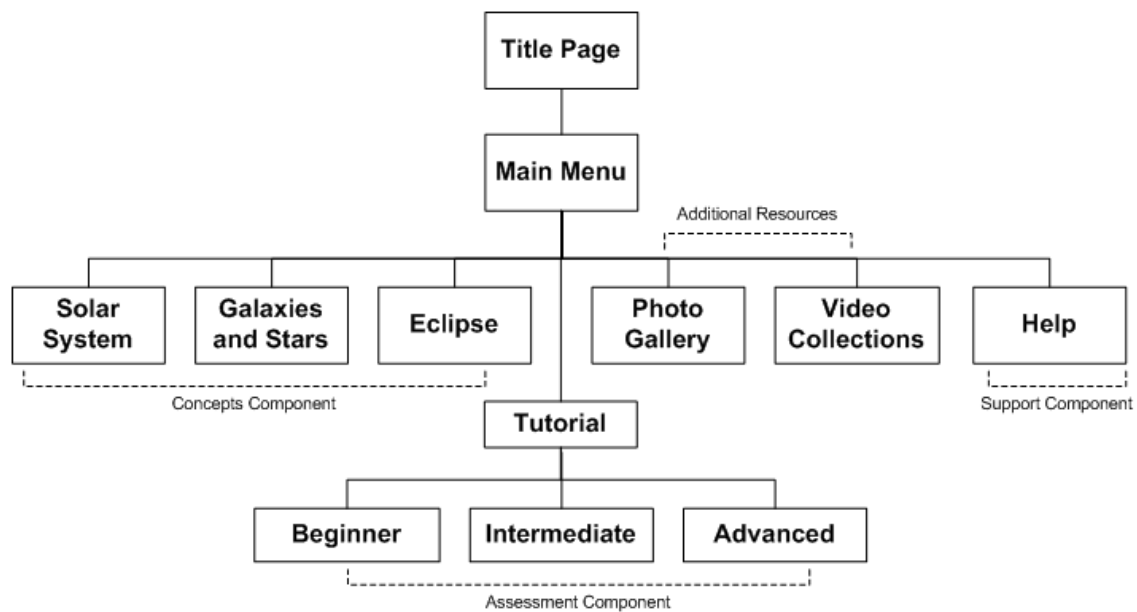


Figure 1. SolMiC Courseware Components

The Concepts component includes theoretical and scientific information on Solar System, Galaxies and Stars and Eclipse. The theoretical concepts have been supported with relevant multimedia elements to engage the student's curiosity and initiate learning. The tutorial component consists of concept oriented questions as well as work out problems. There are two types of questions included in the Tutorial component. Alternate-response questions are those in which the learner chooses correct response or responses from a list. Examples of such type of questions are true or false, matching and multiple choice. The second type of questions is called Constructed-response questions which require the learner to produce rather than select a response. In the developed courseware, this type of question is implemented via completion and short-answer questions and crossword puzzle. Generally, the questions in the tutorial components are organized into three levels of difficulty: Beginner, Intermediate and Advanced. The Photo Gallery and Video Collections are additional resources included in the courseware that offers enhanced exploration and educational enjoyment of the solar system to the students. Finally, the Help component contains user manuals. It explains the general features of the courseware product and how to use them in the form of video.

5.3 Designing the GUI and Screen Templates

Learning events should be designed so as to allow learners to perceive the structure of the event because this will help learners to develop a better understanding of what they are learning [1]. The materials design and development guidelines set out in this courseware are based on hybrid approach. The approach comprises of content design guidelines suggested by [1], [18] and [11]. The guidelines have been customized (as necessary) and adapted to fulfill the scope of SolMic courseware. Table 1 indicates the implemented material design guidelines in the multimedia courseware.

Table 1. GUI and Screen Templates Design Guidelines

| Guidelines | Methods employed by SolMic courseware to satisfy guidelines |
|----------------------------|--|
| Title page | Always provide a title page or splash screen. Make the page clever and interesting but short. If you include movies, speech or animation, allow users to skip them by clicking the mouse on related button. Make it absolutely clear how to continue the program Always include a title, author name, copyright date and a button to exit. |
| Item Association | The same kinds of item are placed together. Those items functionally related to one another, such as text and graphics, are placed together. The order of various elements is logical and systematic. |
| Learning materials | The design includes text, images, audio, video and animations as appropriate. Graphics and animations are used to attract and engage users. All required display components fit into the available space. Information is not crammed on to a single screen. |
| Other kinds of information | Titles are emphasized using larger type size and put at the top of the screen Particular components of a diagram are distinguished using colour. Colour is carefully used as means of grouping and emphasizing. No more than two or three colours at a time are used except where it helps clarify the logical structure of the information. |
| Screen Templates | Templates are consistent in their layout to help learners quickly identify items. Template items appear in the same place on each screen. The title of the materials, individual topics are for the most part placed at then top of the screen. |
| Text | Because of the low resolution of current computer screens, small text is more readable in sans-serif typefaces such as Verdana. Arial has been considered for use in headlines. Usage of font size: Headings 14 to 48 points, Subheadings: Half the heading size. Text blocks: 10 to 12 point. The text is written in 'good' English, in a conventional style, with normal rules of grammar and punctuation applied. The difficulties for learners in scrolling back and forward through a sequence of screens is avoided by presenting the text in sections, each on a single page. Left-justified text is used to format the text, title and headings are centered. Paragraphs are indicated by an additional blank line rather than by indenting the first line. Avoid the use of all caps for text. No more than three text colours are used in a display as learners find it difficult to keep track of different colour codes. A text and background colour combination is chosen that maintains a high contrast between the text and background. Colours carefully used to distinguished and highlight text components. Bold-face and italics are occasionally used for highlighting words or phrases. Blinking or moving text should not be used. Because underlined is commonly used to indicate hypertext, using this technique for emphasis should be avoided. |
| Graphics | The type of graphic used (photographs, illustrations and icons) is determined by reviewing its role or function. A sequence of graphics is used for showing a series of events or a process. The graphics does not distract learners from the materials to be learnt. All graphics have captions or titles. Images with too much detail are not used at a small scale as this detail is lost on the screen. |
| Navigational tools (icon, | Colours are harmonious and kept to a maximum of two. Icons are in regular shape, and positioned on the screen, so the active areas do not overlap. |

| | |
|------------------|---|
| button) | Icons are grouped into their respective categories of navigation (back, next, home, etc). The icon is understandable, familiar, informative and legible. |
| 3D graphics | The graphics is used to encourage three-dimensional thinking The graphics is used in the depiction of objects whose spatial construction is of particular importance. |
| User control | Whenever there are movies, audio or animations, allow the learner to pause, continue, repeat or skip them. A consistent means for moving from one screen or module to the next is provided. A facility is provided for getting back to the main options the program offers. Use button for local controls and very frequent actions. Use menus for global controls and selection of program sections. |
| Audio | Use speech for getting attention, for directions and for dual coding. Files are less than five minutes in length The narration is active and interesting and uses a personal style. There is good tonal variation and voice is clear. The sound volume is consistent from screen to screen. The user can pause and play back the file an unlimited number of times. |
| Video | The video is essential for learning the topic Use video for demonstrating and modeling Users can pause and play back the file an unlimited number of times. Keep video presentation shorter |
| Providing Help | Always provide procedural help Provide information help depending on the program's purpose and methodology. Allow to return to directions at all times Always have a help button visible, reminding learner that help is available. |
| Ending a program | Provide the ability for the user to exit anywhere in a program. Provide a safety net to rescind a request to exit. Return the user to an appropriate place after the program quits. |

6 Courseware Implementation

Generally, the information objects that form visual space of every scene in SolMiC can be grouped into four main categories information objects [13]:

- i. Education materials in the form of texts, graphics, animations, audios and videos
- ii. Identifiers of current location for example chapter titles with icon describing selected component placed on top of the template.
- iii. Navigational tools such as transition buttons, home button and menu
- iv. Service objects like buttons of video control, help, hint.

When student starts the SolMiC courseware, the first screen they will see is the Title Page. The Title Page (Figure 2) is splash screen to tell the student in general what the courseware is about. When the student hit the 'start' button, the 'Main Menu', as shown in Figure 3 will be displayed. From the Main Menu user can go to any modules which are Solar System, Eclipse, Tutorial and so on. Each module's templates are consistent in their layout to provide the student with a consistent user interface. Generally, the first page of each module presents the user with a title of contents on the left frame menu so that they can access any 'page' of the module from this list (Figure 4) page.



Figure 2. Title Page



Figure 3. Main Menu

A series of 2D and 3D animations (see Figure 5), typically consisting of a short sequence of animated graphics, have been created as an aid to explaining the complex concepts for example, the nine planets and their movement around the sun, the phenomena of eclipse, galaxies and stars. An audio narrative explaining the sequence of events on the screen accompanies some of the animations. In fact, these animations are also particularly effective when explaining complex concepts to students from a non-English speaking background, as they transcend the English language [4].

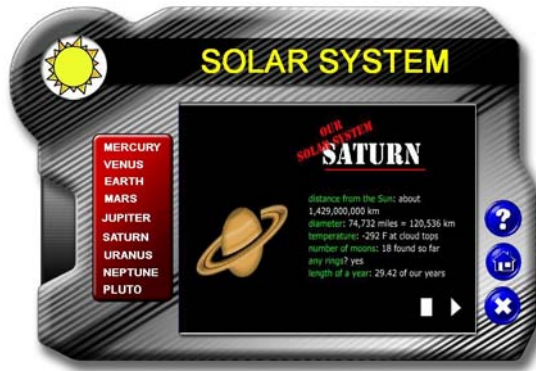


Figure 4. Learning Module

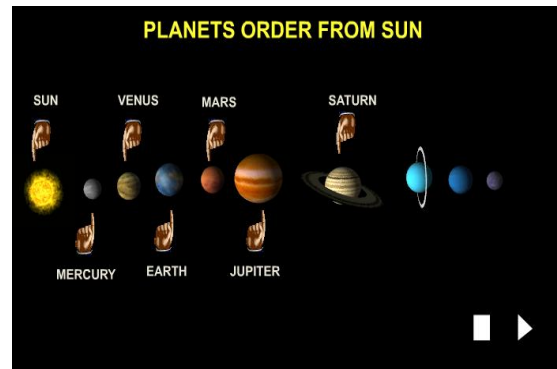


Figure 5. Simulation of Order of Planets from Sun

The courseware prototype is software independent, meaning that the students need not to have access of multimedia or simulation software to use the courseware. However, the Authorware Web Player is required for viewing the courseware. The plug-in will be delivered with the courseware CD.

7 Proposed Courseware Evaluation

The author tried to follow evaluation issues as recommended by Jolliffe (2001) as a guide to the evaluation methodology development. The evaluation method centre on four issues as listed in the Table 2 and addresses both summative and formative procedures need for courseware evaluation. The Learning Material issue refers to the evaluation of overall evaluation of courseware materials while the criteria of the Learning Event Evaluation are based on the events of instructions, as described by Gagne (1977). The evaluation took place in the form of questionnaire and oral formats.

Table 2. Courseware Evaluation Issues

| Issue | Criteria |
|----------------------------|--|
| The learning material | Material Contents Overall Design Interactivity Navigation Motivational Components Media Assessment. |
| Learning event evaluation | Getting the learners' attention Telling the learners where they are going and how they are to get there Helping learners what they have done before and relate it to what is coming up Provide learners with learning materials Showing learners what they have to be able to do to complete the task Having learners practice what they have learnt. |
| Material Design Evaluation | Provide overall design that is both effective and clear to learners Provide learners with new knowledge and skills Provide a graphic design to catch the eye and inform and educate learners about the topic Provide a user interface that has several standard menu options present on every screen. |
| The Learning Environment | Operating System Hardware Software Available peripherals Training |

8 Conclusion and Future Works

This paper has demonstrated the design and development of SolMiC courseware prototype. Throughout the development, a great deal of knowledge has been gained about constructive learning approach; materials design guidelines and courseware evaluation issues. The proposed courseware is expected to inspire the studying interest of students and making the students to have a deeper understanding of the teaching contents through the integration of different media.

In addition to creating courseware content there are a number of future works that might be pursued. Firstly, to transform courseware into version that will run across the World Wide Web. Secondly, to deliver the lesson material via different game modes this approach requires quick reactions and feedback that can stimulate the learning process. Thirdly, the content of the courseware should be in a standard compliant format that can be exchanged and re-used, cross platform and in different delivery environments. For this purpose, there are three

formal standards currently in development: Learning Object Metadata, Instructional Management System (IMS), and Shareable Courseware Object Reference Model (SCORM) [2].

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