

A LEARNING OBJECT IN ENGINEERING EDUCATION: A CASE STUDY

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ABSTRACT

In order to produce quality learning material, one needs to have cognizance of a number of disciplines such as education, technology, aesthetics, and usability. Although experts on each can usually be found, it is often difficult to find a balance between the disciplines and to integrate knowledge from each discipline to the end product. The situation is further complicated by the diversity of cultural backgrounds of end users. In this research we produced a learning tool, paying attention to educational theories, technological standards, and aesthetics of design, and tested the tool with 14 students. Our findings suggest that cultural neutrality can be perceived as blandness, and therefore although it may not irritate the student, it may not stimulate the student either. We suggest that instead of neutrality, adaptivity or adaptability to user preferences should be promoted.

KEYWORDS

e-Learning; Design Issues; Cultural Issues; Multimedia.

1. INTRODUCTION

There is an abundance of theories and models of learning objects and multimedia-based learning material, but there is a gap between those *theories and models* and *actual learning material*. In many cases there are gaps between theories and practices *within* disciplines and *between* disciplines, and not always are the theories within and across disciplines in harmony with each other. It seems to us that *education*, *technology*, *aesthetics*, and *usability* meet quite rarely. The fact that the *end users* nowadays may come from different cultural backgrounds and environments increases the challenge for creating multimedia-based learning material that is of high quality.

We believe that one of the most important aspects of multimedia design is that the designers who work in interdisciplinary teams should be ready to communicate, make compromises, and find the best suitable solutions for their different points of view on how electronic learning material is done. In this paper we present a tutorial that was made with the latest technology at the time, that was based on acknowledged theories of e-learning, and that was designed according to the multimedia design principles. In addition, we present the results of a qualitative research in which the tutorial was tested by 14 students with different backgrounds.

2. LITERATURE REVIEW

2.1 Education

There is no universal agreement on how learning occurs. Today many educators are strong proponents of particular approaches while others combine different theories. In the middle of the 20th century, learning

theories were dominated by the principles of behavioral psychology, exemplified by the work of B.F. Skinner. In the 1970s the behavioral paradigm was expanded to include the ideas of cognitive psychology. In the 1980s the new learning paradigm of constructivism began to influence the educational and instructional design.

Developing learning material for any medium requires understanding and appreciation of different principles of learning. Being familiar with a number of educational paradigms is already a time-consuming and complex task. After the introduction of electronic multimedia that should be adaptable for the needs of different types of learners in different kinds of situations, the educational challenge has become even more complex. Alessi and Trollip (2001) note that some educational methodologies such as tutorials and drills can straightforwardly be developed into electronic multimedia, whereas others are more difficult to implement as multimedia (for instance, simulations and open-ended learning environments). Alessi and Trollip suggest an *Instruction and Learning model* for explaining different methodologies. Their model includes four aspects of successful classroom instruction: (1) Presenting the information, (2) Guiding the learner, (3) Practicing, and (4) Assessing learning.

In concordance to their model, Alessi and Trollip (2001) mention that *a tutorial* is best suitable for the acquisition of knowledge. They suggest that a well designed tutorial program should consist of the following phases (Figure 1). First, inform the learner about the purpose and nature of the program. Second, a tutorial starts a cycle that includes (i) presenting the information, (ii) queries, which can be of the response recognition type in which the learner chooses the correct response, or of the construction response type in which the learner produces a complete answer, (iii) evaluation of queries, and (iv) feedback according which the user can evaluate which elements he or she should take into account in the next iteration. This process is repeated until the tutorial is finished or the learner quits the program.

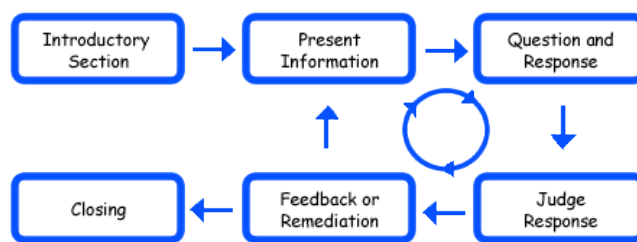


Figure 1: Phases of a tutorial (Alessi & Trollip, 2001)

2.2 Computer Science and Multimedia

Generally speaking, the aim of computer science is to automatize tasks (Denning *et al.*, 1989), which leads to an emphasis on functionality, productivity, performance, effectiveness, interoperability, and reusability. In the area of e-Learning one approach computer scientists use to achieve the aforementioned goals, is the *Learning Object Metadata* (LOM). Examples of small-scale reusable digital resources include digital images or photos, live data feeds (like stock tickers), live or prerecorded video or audio snippets, small bits of text, animations, and smaller web-delivered applications, like a Java calculator (Wiley, 2001). Examples of larger reusable digital resources include entire web pages that combine text, images, and other media or applications to deliver complete experiences, such as a complete instructional event (*ibid.*).

There is empirical support that multimedia information provides learning advantages in several specific situations (Najjar, 1996). According to Najjar (1996), two overlapping media seem to benefit learning more than one medium, but that not all combinations of overlapping media are beneficial. Another potential of electronic multimedia is *interactivity*. Schwier and Misanchiuk (1993) mention that there are three levels of interaction: *reactive*, *proactive*, and *mutual*. Reactive interaction is, for instance, a response to stimuli or an answer to a given question. Proactive interaction emphasizes learner construction and generative activity.

In the design of a multimedia learning program one has to take into account technical, instructional, aesthetic, and usability-related issues. Riempp (2002) suggests a number of aesthetic issues to be considered: Writing style (simple and brief), Narration (prefer the first person subject), Screen Format (one idea per text screen), Grammar (use clear grammar), Numbering (promote bulleted lists), Questions should be numbered, Layout restrictions, Abbreviations, Screen text (font type and effects), Colors, Music, Illustrations, and so

forth. Riempp notes that aesthetic aspects of the project should be consistent all the time.

3. DESIGN AND IMPLEMENTATION OF THE TUTORIAL

The purpose of our research was to design and implement electronic learning material that brings together the ideas presented above (Alessi & Trollip, 2001; Riempp, 2002; Najjar, 1996), and then to test the material with students. The learning program was made for the University of Applied Sciences in Offenburg, and the topic was *transfer function* from the field of Modern Control Systems. The topic has a logical learning sequence, and therefore we chose to implement the program as a *tutorial*, as tutorials are best suited for content with clear, sequential structure (Alessi & Trollip, 2001). We followed the technical standards for learning objects metadata (LOM) as closely as possible (see Wiley, 2001), and we implemented the tutorial with Macromedia Flash 5. With this tutorial we examined how a multimedia application can support and/or improve learning of engineering students.

After we had decided the topic (transfer function) and the format of the program (tutorial), we had to make a number of other decisions related to the production of the multimedia application and to the flow of the content in the tutorial. In addition, we needed to analyze the learning needs and activities, as well as evaluation style and criteria. Our analysis of the above-mentioned aspects, merged with the phases we defined for the tutorial, helped us to construct the structural design of the application. Moreover, we also needed to define which kinds of multimedia would best support our design scheme, and how they would best support each other (Najjar, 1996). We decided that the program was to be a reactive one (see Schwier & Misanchuk, 1993).

We decided that the tutorial adapts to learner response by increasing or decreasing the difficulty level, and that the tutorial starts at an intermediate level. The types of questions that are posed to the learners during the tutorial are mainly alternate- and recognition-response tasks, and in each section of questions, we included at least one constructed response task. The assessment of the response and the following feedback are done immediately every time the learner answers a question. Learner control is implemented by paging (the users decide when a new screen appears).

In the layout of the tutorial, the basic idea was that in order to get the learner's attention, the elements involved in the tutorial should be kept as simple as possible. Our choice of colours was done with a view to give the tutorial a uniform and professional look. As gray colour has been argued to be a neutral color that seldom evokes strong emotions (Holzschlag, 2002), and as we wished to provide a culturally neutral interface to the tutorial, we decided to use different shades of gray in the user interface. We also constructed a help resource that deals with the usage of the tutorial. For screen shots of the tutorial, see Figure 2.

4. RESEARCH METHODOLOGY

The informants were chosen following a purposive sample (Bernard, 1995:95) – Informants for the study were chosen from the students of the *Multimedia Integration Lab* and the *Elektrotechnik* students at the University of Applied Sciences in Offenburg. Note that a qualitative research with a non-probability sample cannot be generalized beyond our sample group (Bernard, 1995:94). However, such research offers an idea of the success of the tutorial with the sample group. The sample included four women and ten men, with diverse nationalities: 6 Europeans (all from Germany), 4 Hispanic (Mexico, Salvador, Guatemala, Spain), and 4 Asians (India, Thailand, and two from China). The language used was English. All but one of the informants had previous knowledge about the topic.

The research part consisted of two parts: an observation and a structured interview. The informants were taken in one by one and they were asked to study the topic (transfer function) using our multimedia tutorial, and a researcher monitored the informant's actions and made notes. Some observation parts took place in different computer labs than the others, yet the interface was always the same. The informants were aware that they were being monitored but there was no discussion between the informant and the researcher during the observation phase. After the informants had studied the topic using our tutorial, they were asked six pre-designed questions in the form of a structured interview.

The observation was an obtrusive one, that is, the informants knew that they were being monitored (Bernard, 1995:310. Note that an unobtrusive approach is difficult to take in this kind of a research). The

researcher monitored the users' reactions to the program, paying specific attention to (1) the time that it took for the users to complete tasks; (2) if users ever got “stuck” with the program; (3) mouse clicks, both those that lead to program actions, and those that did not do anything; (4) the mouse movements on the screen; and (5) the users' general reactions to the program.

The structured interview consisted of six questions: (1) Did this tutorial fulfill the following schema? (See Figure 1); (2) Was the paging control *easy*, *obvious*, and *consistent*?; (3) Do you think media may affect you in how you do learn a material? (if yes why?); (4) Different media have different advantages. With which type or kind of elements of interactive multimedia help you or encourage you to have further analysis and thinking rather to give the correct answer: *graphic*, *text*, *audio*, *speech*, *animation*, *video*, *photos*; (5) This prototype of tutorial for the Transfer Function offers you: *reinforcement*, *attention*, *perception*, *encoding*, *memory*, *comprehension*, *active learning* (also by doing), *motivation*, *locus of control*, *mental models*, *individual preferences*, *knowledge construction*?; (6) Did you perceive any peculiar difference?

The interviewer discussed each of the six question separately, and for questions (4) and (5) each of the items separately. Because the interviewer had also monitored the informants' usage of the program, at some places she also initiated free discussion about the problems that the informant had had with using the program. At the end of each interview, a free discussion about overall image of the program and improvement ideas took place.

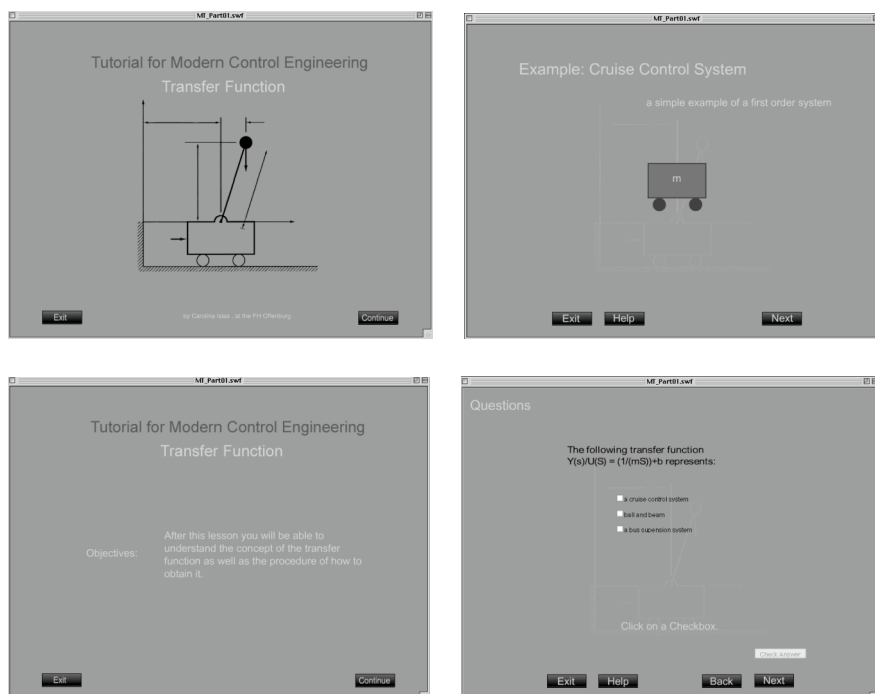


Figure 2: Screen Shots of the Application

5. RESEARCH FINDINGS

5.1 Observations

We noticed that the informants' pace and concentration differed a lot. Some of the informants were careful in their reading and one, from Germany, even recalculated a formula with paper and a pen. Others scanned through the tutorial quite fast. One informant (from India) lost his patience and quit the tutorial before finishing it. In the beginning all informants tried to find out which parts of the tutorial were interactive, or

“clickable”, by trial and error. This trial and error took place after the first animation had finished, and the informants tried to find out if there was something more to the animation. Only one of the informants, one from Germany, used the help option.

In the beginning of each tutorial, each informant exhibited some anxiety about the task. However, towards the end of the tutorial this anxiety was released. This could also be seen in that towards the end the informants began to resolve the questions faster and with more confidence, as they began to see to which concepts they should pay attention. Three of the informants had problems with navigation.

5.2 Interview

To the first question (Did this tutorial fulfill the following schema? (See Figure 1), all of the informants answered that the tutorial did meet the schema.

To the second question (Was the paging control *easy*, *obvious*, and *consistent*?), 11 out of 14 informants answered that the paging control was easy, obvious and consistent. A Guatemalan informant replied that the paging control was not easy, a Mexican informant mentioned that feedback should be improved, and a Thai informant felt that the feedback was “weak”.

To the third question (Do you think media may affect you in how you do learn a material? (if yes why?)), 13 out of 14 informants answered that the choice of medium may affect learning outcomes. A Thai informant replied that the choice of medium does not affect the learning outcome.

To the fourth question (Different media have different advantages. With which type or kind of elements of interactive multimedia help you or encourage you to have further analysis and thinking rather to give the correct answer: *graphic*, *text*, *audio*, *speech*, *animation*, *video*, *photos*.), the replies are shown in Table 1.

To the fifth question (This prototype of tutorial for the Transfer Function offers you: *reinforcement*, *attention*, *perception*, *encoding*, *memory*, *comprehension*, *active learning* (also by doing), *motivation*, *locus of control*, *mental models*, *individual preferences*, *knowledge construction*?) the informants replied as shown in Table 2. In addition to Table 2, three informants noted that elements of *encoding* were supported by the tutorial, three informants noted that elements of *mental models* were supported by the tutorial, and two informants noted that elements of *knowledge construction* were supported by the tutorial.

To the sixth question the informants gave a large number of comments. We classified the comments in five categories: First, there were comments on *Learning the Tutorial* (“by time I knew in what I should put attention”, “try until I get it”, “our brains think in different ways”, “important responses of the system”, “important to feel successful”, “you learn by doing”, “there were language problems”, and “you decided about your own speed”). Second, there were comments on *Media Use* (“make it more entertainment, less boring”, “visual media helps to see the thing in an easier way”, “more interactive gets more attention and it is easier to put it in the head”, “I like the animation, it is good for studying”, “more precise animations”, “see more gaming going on”, “liveliness, need to feel less boring, attractiveness to the brain, same time interesting”, “less formulas”).

Third, there were a number of comments on the *User Interface* (“highlight key words”, “link on key words”, “links more interactive, like to repeat”, “balance text”, “graphic and text for content”, “need more feedback”, and “need more information about the levels”). Fourth, there were comments on the *Use of Colors* (“need bright colors, more attractive colors”, “play more with color, see more connections with the colors”, “better signing, can be done with the use of colors”, “The color is sad”). Fifth, there was some discussion about tutorial as a tool for learning (“tutorial is better than a book but in the lectures we can ask”, and “the type of media depends on what you are doing”).

<i>Medium</i>	<i>Proponents</i>
graphics	13 out of 14
animation	13 out of 14
text	12 out of 14
video	5 out of 14
photos	2 out of 14
speech	1 out of 14
audio	0 out of 14

Table 1: Media Preferences

<i>Cognitive Elements</i>	<i>Proponents</i>
Active learning (also by doing)	10 out of 14
Motivation	9 out of 14
Perception	9 out of 14
Attention	8 out of 14
Reinforcement	7 out of 14
Comprehension	4 out of 14
Memory	4 out of 14

Table 2: Elements of Cognition Supported by the Tutorial

6. DISCUSSION

We noticed that even though all the informants were confused about the tutorial at some points, and that even though some informants even tried to ask the observing researcher help about the interface, only one informant actually used the *help option*. Most used trial and error technique to solve their problems. Although we do not know the reason for not invoking the help option, the lack of its use suggests that it is important to build the user interface as intuitive as possible. However, it is not certain whether intuitiveness of interface elements and functions is a culture-independent aspect or whether people from different cultures have different intuitions about user interface elements. Overall, the paging and control designs were given a good reception.

The fact that the informants preferred *graphics*, *animation*, and *text* to other media (Table 1) may be due to the fact that the preferred media were the same with the media present in the tutorial. We suggest that a new study in which the three least preferred media are used in a similar tutorial might reveal if the preferences are set by the presence of the media in the tutorial. One of the informants stated that media do not affect his learning, and he noted that he gets the best learning results by reading a book and discussing the topic. We interpreted many of the informants' difficulties as problems with focus, because the difficulties seemed to arise from a lack of attention, such as not reading the title or instructions.

The majority of the informants believed that *active learning*, *motivation*, and *perception* can be supported by this kind of tutorial. However, because the informants were media and technology students, we should have offered a more detailed description of what the terms such as *reinforcement* in this question mean. It should be noted that less than half of the informants believed that this kind of a tutorial can support

comprehension and *memory*. This is in clear contrast with the fact that 13 out of 14 of the informants said that they had learned the topic.

Although we did not expect culture to have any influence on learning style, we noted a number of preferences that we connected with cultural backgrounds of the informants. In this sample of informants, the informants with German origins paid the most attention on reading, and at the same time, the European informants reported most language problems. All the German informants and none of the other informants suggested that there should be a co-relation between figures and formulae, marked with colors. The informants with Hispanic origins did not read as carefully as the German informants did, and the Hispanic informants attacked the questions faster. All the Hispanic informants and none of the other informants commented in the interview that they found it interesting to try to find the “trick” on how the tool was working. We did not find any notable commonalities in the actions or comments of the informants with Asian origins.

7. CONCLUSIONS

The design of a multimedia learning tool nowadays needs to incorporate knowledge from very different areas such as technology, education, aesthetics, and usability. It is difficult to implement the tool without emphasizing some of these areas at the cost of others. For instance, emphasizing educational theories may happen at the cost of aesthetics of the learning tool. On the other hand, an aesthetically pleasing tool may not be in accordance with acknowledged educational theories. We found out that it is difficult, but not impossible, to combine all these aspects, but that paying attention to all these at the same time complicates the design and implementation task immensely. Although the design teams have different specialists for each discipline, our experience is that there should be one person with knowledge of all the disciplines.

Although our research is not generalizable as such, we found out that the cultural backgrounds of the users may affect their perceptions of aesthetics and usability. Our design emphasized *neutrality* in the choices of colors, but we found out that none of the informants liked neutral colors – however, the suggestions of how to use more colors were diverse. On the other hand, there was not that much divergence in the preferences of different aspects of multimedia – text, animations, and graphics were preferred to video, photos, speech, and other audio. We believe that further research about the effect of culture on the multimedia design choices should take place. We also believe that the learner's background may affect how much and what kinds of interactivity the tool should exhibit.

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