December 2006

Use of Multimedia Case Studies to Teach Technical Subjects: A Multiple Experimental Study

Victor Mbarika
Southern University

Chetan Sankar
Auburn University

Pratim Datta
Washington State University

Belinda Shipps
University of Wisconsin-Milwaukee

Use of Multimedia Case Studies to Teach Technical Subjects: A Multiple Experimental Study

Victor W. Mbarika
Southern University
victor@mbarika.com

Chetan S. Sankar
Auburn University
sankacs@auburn.edu

Pratim Datta
Washington State University
pdatta@wsu.edu

Belinda P. Shipps
University of Wisconsin-Milwaukee
bshipps@uwm.edu

Abstract

A review of "social experiments" with adoption of multimedia-based technologies in Europe has been reported. But, there has been limited discussion on the value of multimedia instructional materials in technical disciplines. This study combines results from experiments carried out over a period of three years with multiple audiences -- IT managers, business, and engineering students -- to examine if multimedia case studies do improve perceived higher order cognitive skills and if so, what accounted for such improvements. Among all the experimental groups involved, this study found that people reported improvements in perceived higher order cognitive skills, self-reported learning, learning interest, challenges to their thought process, and learning from others.

Keywords:

Multimedia, Higher Order Cognitive Skills Development, Instructional Technologies

INTRODUCTION

The pedagogy of teaching technical concepts and issues has been a challenge in both work and educational environments. Examples of such pedagogically complex concepts are those taught in areas of engineering and information technology such as operating systems architectures, vibration, thermodynamics, satellite technologies and expert systems. The subjects are normally difficult to communicate and convey to students, thereby contributing to many students' lack of interest and attention to these areas.

In addition to the technical skills, many employers and top executives in companies recognize the value of workers who possess good decision-making skills in terms of their ability to solve problems in areas such as competitiveness, performance and sustainability. They want their managers and workers to be above average problem solvers, decision-makers, and team players (Rieley and Crossley, 2000). The National Aeronautics and Space Administration (NASA) is one example where it is working to boost decision-making skills. NASA instituted more aggressive decision-making training after discovering that the second major cause of flight-crew related accidents was decision errors (Dornheim, 2000)

IT employers in particular expect graduates to possess good decision-making skills and higher-order cognitive skills. Higher-order cognitive skills are skills that go beyond basic comprehension of a problem or concept. They consist of skills such as identification of problem, analysis of issues, figuring out alternatives, evaluating alternatives, and making a choice. These employers expect students to sharpen their decision-making skills and make trade-off decisions that translate technical impact into business impact. Undergraduate students have to understand and speak the language of management, in addition to making decisions in their technical area of expertise (England, 1998). Many of the purely information technology jobs are being increasingly outsourced to foreign countries thereby requiring more emphasis on learning decision-making skills.

Many studies show that multimedia instructional materials can help improve higher-order cognitive skills, which are needed for handling complex decision-making situations such as those mentioned above. Multimedia-based instructional materials

have been identified as an important tool for managers and students in their efforts to connect and apply classroom, theory-based learning, with the analysis of real-world problems (Raju and Sankar, 1999; Mbarika, et al., 2003).

Multimedia instructional materials are those materials used for instruction that include one or more media such as graphics, video, animation, images, and sound in addition to textual information (Fetterman, 1997, Beckman, 1996). In evaluating previous research, the specific aspects of multimedia instructional materials that contribute to a perceived improved handling of difficult concepts and ideas associated with higher order cognitive skill improvement have not been addressed. Typically, individual abilities have been emphasized as key to learning these tasks. However, Dillon and Gabbard, (1999) suggest that the fit between an individual's learning style and the learning method is also an important consideration. Their study suggests that there is a relationship between multimedia, learning tasks of the individual, and the learning outcomes.

In the following sections, we discuss the research model and the variables that were used to operationalize the model. This is followed by a summary of the three multimedia instructional materials that were used. The experiment is described next with an explanation of the research participants and the two research questionnaires that were used to measure their perceptions of improvements in higher-order skill development. This is followed by a discussion of the experimental results. The results of the experiment reveal significant findings on the ability of multimedia instructional materials to improve perceived higher-order cognitive skills. This is followed by a discussion of findings and identification of future research topics.

RESEARCH MODEL AND QUESTIONNAIRE

The research model is presented as Figure 1 and shows the impact of multimedia instructional materials on "perceived higher-order cognitive skills," "self-reported learning," "learning interest," "learned from others," and "challenging" constructs.

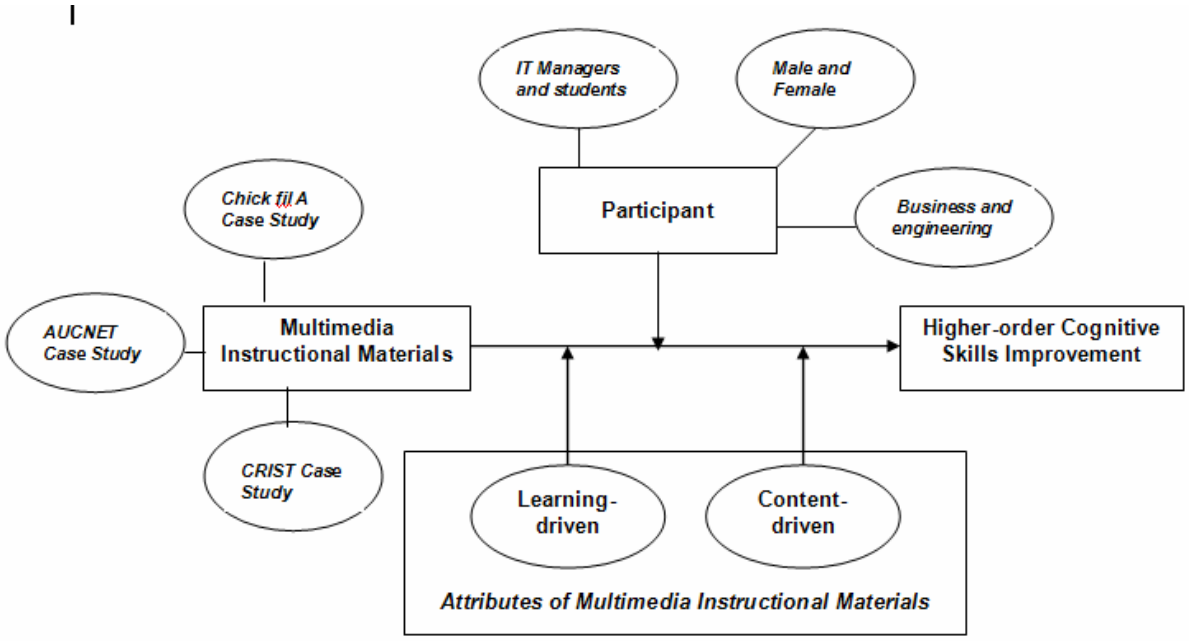


Figure 1: Perceived Impact of multimedia instructional materials on higher-order cognitive skills.

The constructs used in this model (higher-order cognitive skills, self-reported learning, learning interest, learned from others, challenging, multimedia instructional materials and participants) are explained below.

Higher-Order Cognitive Skills

Higher-Order Cognitive skills relate to the perception that an individual has acquired an adequate portfolio of skills to make a decision within a specified period of time. It implies an improved ability to identify, integrate, evaluate, and interrelate

concepts within the case study, and hence make the appropriate decision in a given problem-solving situation. This construct was derived from Hingorani et al. (1998) study and includes the following items: Identify, integrate, evaluate, confident, interrelate, connect, decision-making, and problem-solving. Table 1 summarizes the constructs and the items that were used to measure the constructs in the research model.

Construct	**Definition**	**Items**
Self Reported Learning (3 items)	Measure of student's improvement of basic concepts and of identification of central management and technical issues through use of case study	Improved my understanding of basic concepts, learned new concepts, learned to identify central management and technical issues. (Hingorani et al, 1998)
Learning Interest (3 items)	Measure of the level of student interest generated from the case study	Discussed technical and managerial issues outside of class, did additional reading on technical and managerial issues, did some thinking for myself about technical and managerial issues. (Hingorani et al, 1998)
Learned from Others (2 items)	Measure of how much the students learned from each other by valuing other student's point of view or interrelating topics and ideas	Learned to value other students' point of view, learned to inter- relate important topics and ideas. (Hingorani et al, 1998)
Challenging (4 items)	Measure of case study's success in bringing real-world issues and problems to the classroom	Successful at bringing real life problems to the classroom, challenging, helpful in learning difficult topics, helpful in transferring theory to practice. (Hingorani et al, 1998)

Table 1: Items used to measure the constructs

Participants in Experiment

The case studies were administered in several different classes over a three-year time frame. The participants were segmented into three groups. The first group compared learning outcomes of 50 IT managers from a credit card processing company, to learning outcomes of 82 students from a major southeastern university. The second group compared learning outcomes of 99 male students, to learning outcomes of 41 female students from a major southeastern university. The third group compared learning outcomes of 43 business student majors, to learning outcomes of 42 engineering students from a major southeastern university.

Multimedia Instructional Materials

Each case study used in this experiment brings real-world problems from business and engineering companies live into the classroom. A summary of the case studies and how they were implemented in the classrooms are provided next.

(a) Crist Power Plant case study:

Students played the role of a plant manager and worked with an expert system to refine their decisions and chose among multiple alternatives for maintaining a turbine-generator at a power plant with a cost impact of $2 million. The multimedia CD-ROM introduces the problem with a video where the plant manager discusses the problem and provides the assignment. This case study illustrates a real live plant outage planning and implementation process. Concepts covered include: project management, planning, vibration principles, and decision-making.

(b) Chick-fil-a Case Study:

Students played the role of an MIS executive who had to choose between two operating systems, (Microsoft CE or NT) for use with the company's Point-of-Sale system. Since the Chick-fil-A chain operates over 700 corporately-owned

stores, this changeover had about a $3.29 million investment impact. In addition to this, a tutorial provided background information on Windows CE and NT. Concepts covered include: operating systems, business-technology alignment, Joint Application Development Process, and User Interface issues.

(c) AUCNET USA Case Study:

Students played the role of managers for this on-line auto auction company who had to choose between a satellite network, network based on low earth orbiting satellites, or a network based on Internet technologies. The top management was concerned that the e-commerce company had not made a profit since its inception and was dependent on capital infusion from AUCNET Japan to function. The number of dealers had dropped from 700 at the peak to 300. Concepts covered include: entrepreneurship, e-commerce technologies, strategic planning, satellite technologies, and Internet technologies.

The case study CD-ROM introduces the problem to the students with a video of the manager sharing the problem followed by a thorough explanation of the issues and criteria used to solve the problem. A video of the manager provides the assignment to the students. The students play the roles of the engineers/ managers and analyze and solve the problem. They present their findings using a PowerPoint presentation and a written report. The instructional materials included the following multi-media components:

- Videos, audios, photos, and animation augmented the student's ability to grasp the complex business and engineering materials and made it possible to apply theories they had learned in other classes to solve the problem. Figures 2 and 3 illustrate photos used on the main screen of the Crist case study.
- As shown in Figures 2 and 3, many of the screens were accompanied by a video; student shad the option to play the video or read the text version of the case study related to that screen.

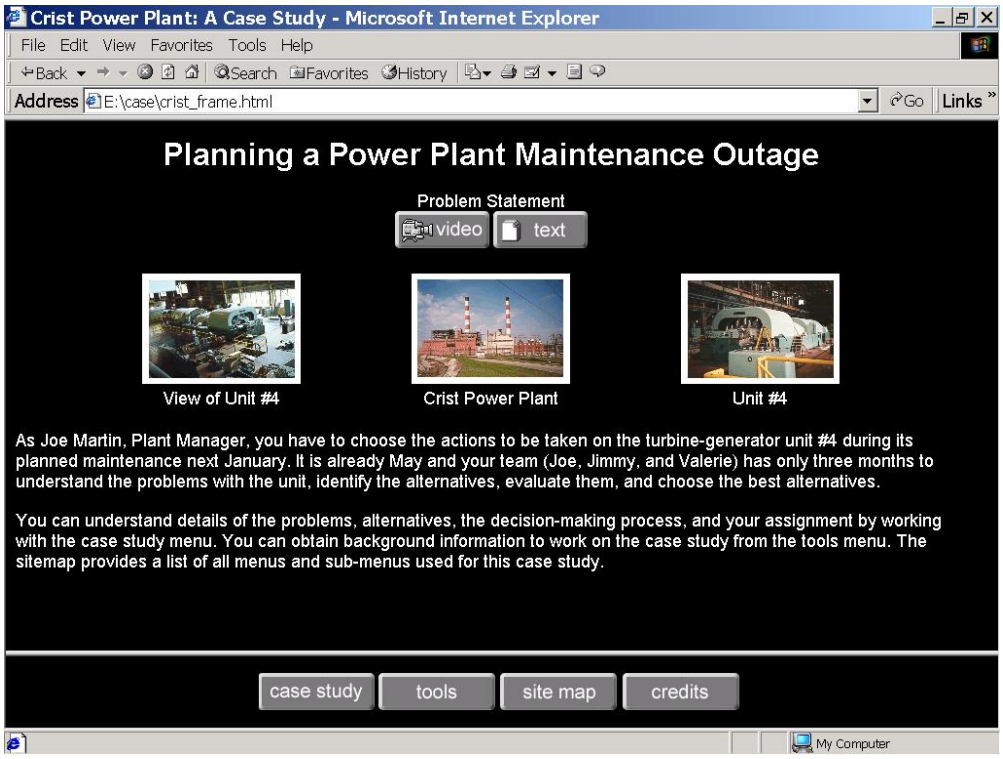
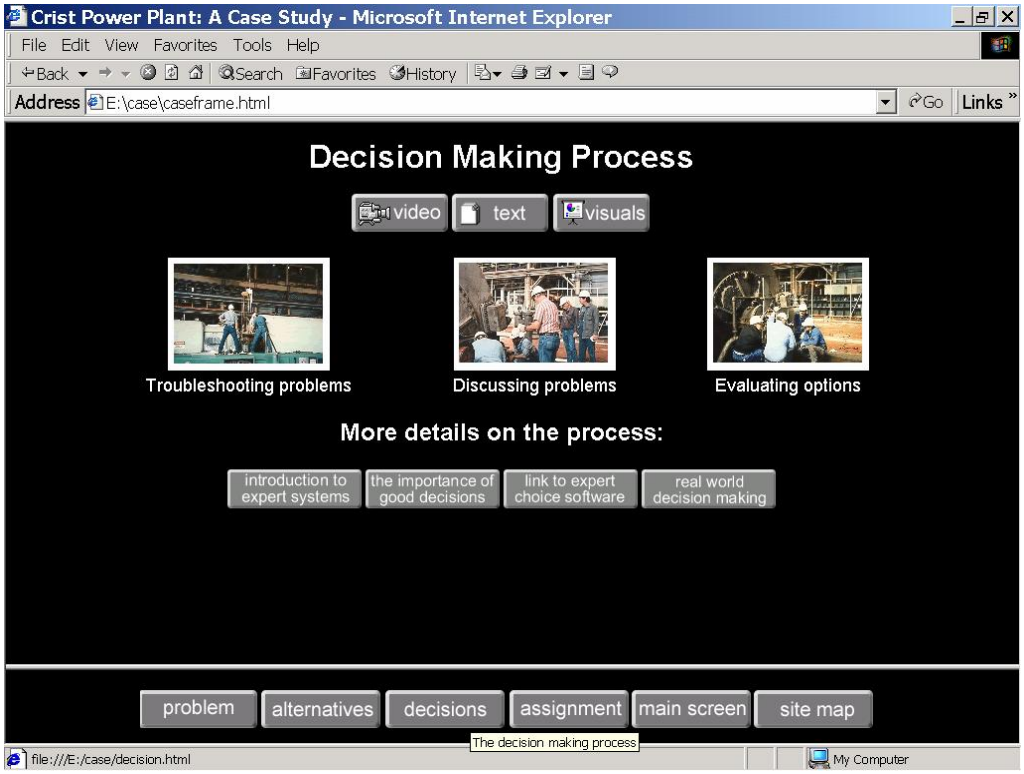


Figure2 : Snapshot of Screen Design



Figures 3: Snapshot of Screen Design

Survey questionnaire

A survey was developed to evaluate whether the case study (a) successfully brought real life problems to the classroom, b) was helpful in learning difficult management and engineering topics, and c) was helpful in transferring theory to practice. These were very important issues to evaluate considering the many challenges that instructors encounter in bringing real world problems to the classroom in a manner that can be grasped by the students, instead of basing learning on theory alone.

The questions were similar to those used in earlier studies (Hingorani et al., 1998; Goodhue and Thompson, 1995, and Mbarika et al., 2001) thereby reinforcing construct validity. The students were asked to evaluate the effectiveness of the method in understanding a typical issue faced by a manager. The survey consisted of items that measured the constructs of *learning interest, challenging, self reported learning, learned from others* and *higher order cognitive skills improvement (Table 1).*

RESULTS

The results of analyzing the responses from the students is provided in Table 1. The means and Standard deviation for all three experiments are shown in this table (Table 2). The value of the mean for all the constructs is above 3 (neither agree nor disagree) showing that the students perceived improvement in all the constructs irrespective of the group that they belonged to. In addition, the difference between the following groups and constructs was significant at a 0.01 level

	Experiment 1 *(Chick fil A Case Study administered within a one-year period)*		Experiment 2 *(CRIST Case Study administered within one and a half year period)*		Experiment 3 *(AUCNET Case Study administered within a three- year period)*	
	Mean (s.d.) IT Managers	Mean (s.d.) Students	Mean (s.d.) Business	Mean (s.d.) Engineering	Mean (s.d.) Female	Mean (s.d.) Male
LEARNING-DRIVEN CONSTRUCTS						
Higher Order Cognitive Skills Improvement	3.48 (.67)	4.19 (.52)	4.02 (.44)	3.65 (.86)	4.00 (.52)	3.70 (.60)
Self Reported Learning	3.59 (.70)	4.20 (.47)	3.66 (.53)	3.58 (.85)	3.80 (.67)	3.61(.66)
Learning Interest	3.36 (.71)	3.68 (.64)	3.69 (.75)	3.26 (1.04)	3.00 (.85)	3.20 (.82)
Learned from Others	3.66 (.75)	4.12 (.66)	4.012 (.48)	3.54 (.81)	3.97 (.56)	3.73 (.67)
Challenging	3.61 (.72)	4.16 (.51)	4.09 (.41)	3.61 (.84)	4.01 (.58)	3.78 (.65)

Table 2: Descriptive Statistics for the Participants in the different experiments

Note: Questionnaire administered using a 5-point Likert scale (1 indicating an extremely negative rating and 5 an extremely positive rating).

Findings

Self-Reported Learning

The results indicate that IT managers and all experimental student groups perceived an improvement in their self-reported learning. This suggests that multimedia improved participants' understanding of basic concepts, new concepts, and helped them to identify central management and technical issues from the case study. This confirms the finding from Ehrlich & Reynolds (1992) study where they state that multimedia provides an opportunity to reach people with different learning styles, different skill levels, and also offers the potential to reduce the learning curve and accelerate the learning process. Reinforcing this finding, some survey participants-- IT managers and all the experimental student groups-- commented:

> *I practiced breaking down a problem situation and looking at all component aspects of the problem including costs vs. risks, materials available, and use of resources to make an intelligent decision on how to treat the situation at hand. I learned that a new product may not always be the correct choice based on compatibility issues and cost analysis vs. functionality.*
>
> *I learned about the many different risks that are involved in making decisions. It is helpful information to use when making any kind of engineering decision.*
>
> *Currently, I work at the Information Technology Help desk and I can tell how much the class has affected my work. I am able to speak about the technical aspects with others and understand what they are talking about. I'm not sure specifically how I could use the information I'm learning today for my future career. Technology changes so rapidly that what I learn today may not be the way it is done in the future. However, this material is giving me the foundation I need to build on so that I'll be ready for the next change.*
>
> *This has been the most informative and fun learning experience I have had in my college experience.*

> *I learned how to use the available technology to solve business problems. I feel more confident now when it comes to talking to others about the specifics of telecomm.*

Learning Interest

The perceived learning interest of the IT managers and all the experimental student groups were more enhanced and sparked participants' interest during and after the experimental class sessions. Some of them commented.:

> *I find the material relatively simple to understand. Keeps me interested in learning more about current and past issues.*
>
> *I have enjoyed working on an actual problem. This really keeps me interested because I see the theories that I learn in school applied in a practical environment. I also enjoy the simulated responsibility of studying the problem from different points of view, and from the information given, generating questions and at least forming a personal opinion on how the situation should be handled.*
>
> *I was very interested and impressed by the Expert Choice software used in analyzing the various options. I had never previously seen such a decision-making aid.*
>
> *I have enjoyed working on an actual problem. This really keeps me interested because I see the theories that I learn in school applied in a practical environment.*
>
> *I enjoyed learning about how the telephone systems work. It's fascinating to me how it works and most of the time we don't even think about it – we just take it for granted.*
>
> *I thought that the material was very interesting and related well to the technology we are already familiar with.*
>
> *Keeps me interested in learning more about current and past issues.*
>
> *I enjoy all of it, it is going to be my career and I enjoy learning.*

This finding agrees with the Jonassen, 1989 study which states that multimedia is attention capturing and engaging to use. Another important fact associated with enhancing learning interest is that we observed that the IT managers and the students discussed technical and managerial issues even after the case study sessions; a rare occurrence indeed in academic settings where students get bored quickly with topics and lectures.

Learned from Others

The IT managers and all the experimental student groups perceived that they learned from others with multimedia during their group interactions. In this respect their perception relates to learning from their group members by discussing and interrelating important topics and ideas. The findings reinforce past studies which indicated that multimedia increased interaction among students (Adams et al., 1996; Goodrum et al., 1993). Some students commented:

> *I have learned to be more open to new material and ideas and really learn from them.*
>
> *I feel that through understanding the material I had to look at problems from every angle and even listen to others' viewpoints in order to solve the problem. I feel I have become better at problem solving.*
>
> *I also enjoy the simulated responsibility of studying the problem from different points of view, and from the information given, generating questions and at least forming a personal opinion on how the situation should be handled.*

Overall, the students enjoyed learning from others as they worked with the instructional materials as can be noted by their following comments:

> *As I worked with my group, they brought up ideas, viewpoints, and questions that I had not thought of myself. This helped to quickly expand my knowledge of the case and develop a defense for our chosen method to solve the problem at hand.*
>
> *When engineers work together, it seems that the product is more than the sum of the individuals. I think I'm starting to learn just how powerful a few motivated engineers can be when they work together.*
>
> *I enjoyed hearing my groups points on which one they think is the best, worst and why. It was interesting to hear what they had to say and* why they chose which options. This was interesting to see what different people come out with different ideas even though we all read the same thing.
>
> *While working on the presentation, I learned that working with a group gives new perspectives at the topic. There are many different ways of looking at something and many solutions to problems as well.*
>
> *…the most enjoyable aspect to the case study is the group work that is involved with the case study participation.*

Challenging

The IT managers and the students perceived that the material was challenging and fostered teamwork. Woolf and Hall (1995) believe that the multimedia approach challenges students to want to learn. DiPasquale and McCabe (1993) argue that multimedia makes students really sit up and focus on what's going on. Some students commented:

> *I enjoy learning about the material that is presented to me because it stimulates my thinking which makes me think that I'm in the right major.*
>
> *I enjoyed the challenge of the case study. One of the reasons I chose to become an engineer is because I love challenges. Challenges are sometimes the best way to learn.*
>
> *It was difficult to decide which option would be best. There were enough missing variables that we did not have complete information about that made the decision tough, i.e. the condition of the spare stator bars. The number of options also made it challenging.*

These findings indicate that designers of instructional materials for difficult technical and engineering subjects, whether in an academic or business-related environment, need to include materials that will help enhance self reported learning, improve learning interest, provide opportunities to learn from others, and is challenging.

DISCUSSION: BUSINESS/ACADEMIC IMPLICATIONS

The findings show how multimedia aids in development of perceived higher order cognitive skills. In light of rapid technological developments, the effectiveness of instructional design hinges upon increasing cognition of complex concepts for better and faster decision-making. Not only is there evidence that computerized multimedia instruction is important to cognition in terms of time, one study indicated a 88% reduction in learning time (90 minutes versus 745 minutes) (Kulik, et al, 1983), but also in terms of effective delivery of complex information. A study by Mayer (1993) found that multimedia instruction provided individuals with low prior domain knowledge ability to build cognitive models of systems. These findings suggest important ramifications for use and development of multimedia-based materials as an aid in development of perceived higher order cognitive skills. Multimedia-based learning and decision-making tools were found to help in development of other perceived skill such as challenging, learning interest, learning from others, and self-reported learning. These results have implications for organizations and learning institutions pertaining to:

- Adapting to different learning styles
- Enhanced and increased group-collaboration

Adapting to Different learning Styles

Various people have different learning styles and a person's method of learning can be an important consideration when developing a learning environment (Fahri et al, 2001). Multimedia-based learning addresses the issue of different styles of learning by providing different means of presenting the information. Soloman's (1992) inventory of learning styles develops a typology of different ways students learn. The typology classifies learning types into four categories: processing, perception, input, and understanding. Processing involves the physical (active) or mental (reflective) manipulation of the information provided; Perception is driven by sensing (observation) or intuition (reasoning); input varies between using visual or verbal information; Understanding involves a sequential (linear step-based approach) or global (ultimate objective driven) approach. The diversity of learning styles is exhaustively examined by Soloman (1992) who found that majority of students are active processors, driven by sensing, prefer visual input, and find sequential learning to be more coherent. For example, individuals who learn by watching or seeing may focus more on videos, graphics and animation. Learners that focus more on feeling and doing can also benefit from watching video and sound in which they can view actions and see and hear the feelings of the subjects in the context of the problem situation. Yet, as Felder and Silverman (1988) bemoan, there exists little pedagogical support that addresses the diversity, calling for newer and more effective tools and techniques to enhance the learning process across diverse styles. In that aspect, multimedia seems to emerge as a potential candidate of choice to help students with different learning styles. This is reinforced by the finding from our study where IT managers or students, business or engineering students, men or women responded favorably to all the case studies even though it was implemented in different classrooms by multiple instructors.

By adapting to learning style, multimedia instructional materials might motivate and encourage students to enter fields such as business or engineering. It may also help increase the diversity in male-dominated fields by increasing understanding and competency and lessening some of the limitations of text-based learning materials that one group may encounter over another. This may help in attracting and retaining individuals who may find technical fields to be boring and difficult to learn or where they may feel pressures from stereotypical feelings of inferiority. Women and other under-represented groups in fields such as engineering and computer science may be more encouraged to enter these fields if different multimedia approaches to presentation of the materials are used that are more amenable to their understanding of the subject matter. It is possible that multimedia instructional materials might balance the inequalities found in many countries: such as in India where the current base of IT professionals is 85% men and 15% women; U.S., where the technology workforce consists of 29% women and 71% men. This also might lead to development of multimedia-based training materials in order to foster self-motivated, self-paced and continuous learning by employees or students.

Enhanced and Increased Group collaboration-based Learning

Recognizing the value of multimedia can be beneficial to the employees in companies since they can increase the growth of organizational knowledge by encouraging knowledge sharing and collaboration. The emergence of digital audio and video technologies that can computationally compress, manipulate, and transmit content over distributed communications networks has brought the world closer. In addition, steady technological innovations and infrastructure developments, especially increased bandwidth availability, are augmenting developments in remote collaboration (Gale, 1992). Gale (1992) found that the collaborator's (learner's) perception of productivity significantly increases with the availability of multimedia technologies. Two trends are fueling the promise of multimedia as a ubiquitous learning technology: the fact that multimedia allows for both synchronous and asynchronous collaboration; and the growth of broadband Internet as a potential delivery medium. Altogether the facts point towards vast improvements in cooperative enquiry (Bargeron, et al. 1999).

The recognition that multimedia can help improve an individual's learning can encourage more group-oriented efforts where individuals may collaborate with others in making critical decisions pertaining to issues such as project management, product design, marketing promotion, and customer/supplier decisions. This could have cost-saving implications through the efficient use, retention, and sharing of knowledge.

Although technical improvements in the production of learning materials do not infer pedagogical efficiency, it does move learning a step close to the learner. Pedagogical efficiency then becomes a function of content effectiveness rather than content delivery. The learning scenario is transformed from a static rule-based one-way control to a much more learner-empowered interactive and dynamic environment. The rich interaction and adaptability that is imperative for learning technical subjects might be satisfied through the use of multimedia. No longer captive to the static delivery of didactic content, technical education teachers can concentrate on exploring new and relevant content pointing to the needs of the learner.

CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

This study evaluates the effectiveness of multimedia instructional materials in conveying technical issues to IT managers and students. The results show that the IT managers and the students who participated in multimedia case study exercises perceived improvement of their higher-order cognitive factors, self-reported learning, learning interest, challenging, and learning from others constructs.

This study shows that the traditional lecture methodology is not sufficient in presenting complex engineering and technical information and it is important to develop tools such as multimedia CD-ROMs that provide the students an ability so bring real-world issues into classrooms. For the learning process to be effective, the audience needs to be challenged, and provided opportunities for learning from self and from others. If this finding is replicated in other settings, it may identify the need to create a wider set of multimedia instructional CD-ROMs that could be used to communicate complex IT and engineering problems to students. The positive results from this study and the findings from the literature indicate that it is critical that multimedia materials be developed for further use in technical and engineering fields to bring real-world issues into classrooms.

ACKNOWLEDGEMENTS

This is a combination of multiple experimental studies funded by the National Science Foundation under Grant Nos. DUE# 9752353, 9950514, 0089036, and 0527328. The experiments span a three-year period. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

1. Adams, D., Carlson, H., and Hamm, M. (1996). *Cooperative Learning and Educational Media: Collaborating with Technology and Each Other.* Englewood Cliffs, NJ: Educational Technology Publications.
2. Bargeron, D., Gupta, A., Grudin, J. Sanocki, E. & Li, F. (1999) *Asynchronous Collaboration around Multimedia and Its Application to On-Demand Training.* Collaboration and Multimedia Systems Group: Microsoft Research, Redmond, WA.
3. Dillon, A. and Gabbard, (1999). *Hypermedia as an educational technology: a review of the quantitative research literature on learner comprehension, control and style* Review of Educational Research, 68 (3), 322-349.
4. DiPasquale, R. & McCabe, S. (1993). Multimedia in the Classroom. *Community College Times*: High Technology.
5. Dornheim, M. (2000). NASA Working to Boost Decision-Making Skills. *Aviation Week & Space Technology*, 153 (3).
6. Ehrlich, D. and Reynolds, L. (1992). Integrating Instructional Design and Technology: A Model and Process for Multimedia Design. *Interactive Learning International*, 8(4), pp. 281-289.
7. England, J. (1998). For Success, Take Charge of Your Career. *Electronic Engineering Times*, (1023).
8. Felder, R.M. and L.K. Silverman (1988). Learning and Teaching Styles in Engineering Education, *Engineering Education*, 78 (7), 674-681, April 1988
9. Gale, S. (1992) Desktop video conferencing: Technical advances and evaluation issues, *Computer Communications*, Vol. 15, No. 2, October, pp. 517-526
10. Goodhue, D. and Thompson, R. (1995). Task-technology fit and individual performance. *MIS Quarterly*, June 95, 19(2), p. 213.
11. Goodrum, D. A., Dorsey, L. T., & Schwen, T. M. (1993). Defining and Building and Enriched Learning and Information Environment. *Educational Technology*, 33(11), pp. 10-20.
12. Hingorani, K., Sankar, C.S., and Kramer, S., (1998). Teaching Project Management Through an Information-Technology Based Method. *Project Management Journal*, March '98, 29(1): pp. 10-21.
13. Ingwersen, P. (1996) Cognitive Perspectives of Information Retrieval Interaction: Elements of a Cognitive IR Theory. *Journal of Documentation*, 52(1), 1996, pp. 3-50.

14. King, N. (2000). Preparing Students for the New Millennium and Beyond. *Education*, 121 (1). Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer-based teaching on secondary school students. Journal of Educational Psychology, 75, 19-26.
15. Mayer, R. E. (1993). Illustrations that Instruct. In R. Glaser (Ed.), Advances in Instructional Psychology. Hillsdale, NJ: Lawrence Erlbaum Associates
16. Mbarika, V., C. S. Sankar, P. K. Raju, and J. Raymond (2001). Importance of Learning -Driven Constructs on Perceived Skill Development when Using Multimedia Instructional Materials. *Journal of Educational Technology Systems*, 29 (1), pp. 67-87.
17. Mbarika, V., Sankar, C.S., Raju, P.K. (2003). Role of Multimedia Instructional Materials on Multicriteria Technology and Engineering Decisions. *Decision Sciences Journal of Innovative Education*, Vol. 1, #2.
18. Raju, P.K., and C. S. Sankar (1999). "Teaching Real-World Issues Through Case Studies," *Journal of Engineering Education*, 88(4): 501-508.
19. Rieley, J. and Crossley, A. (2000). Beyond 2000: Decision Making and the Future of Organizations. *National Productivity Review*, 19 (2).
20. Sauter, V. (1999). Intuitive decision-making. Communications of the ACM, 42 (6), pp. 109-115.
21. Soloman, B.S. (1992). *Inventory of Learning Styles*, North Carolina State University Paper
22. Woolf, B. P., and Hall, W., (1995). Multimedia Pedagogues: Interactive Systems for Learning. *IEEE Computer*, 28 (5), pp. 74-80.