Multimedia Instructional Design for Asynchronous Learning in Engineering

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Abstract

It has been repeatedly shown that students benefit from a multimedia learning environment in which both text (words) and images (graphs, animation, and video clips) are used in the instructional design (ID). This is particularly true when many students, for a variety of reasons, have vastly different learning styles. Research has shown that multimedia approach of ID can provide high quality asynchronous learning courseware. In this paper, we report our work on the ID of an undergraduate course on nanostructure materials and devices, which will a part of the curriculum for the newly announced online Bachelor¹s of Engineering in Electrical Engineering (BE3) degree program to be offered jointly by three major university centers of the State University of New York (SUNY). The program represents the first online degree in the scientific or technical disciplines for SUNY's 64 geographically dispersed campuses. Students from various parts of New York, some urban and rural, learn in different ways, with vastly different cognitive styles and sensory preferences.

Clark and Mayer[1] found much improved understanding when images are added to text in ID. According to a dual encoding theory, instructional materials communicated with both text and images have much higher probabilities for encoding into long-term understanding and retention. By employing a direct hands-on/minds-on visual/text approach, the ID of web-based asynchronous learning endeavors to remove many of the conventional barriers that hinder effective teaching and learning of seemingly abstract electrical engineering concepts by reducing the "interfaces" between the learner and the concept. The project, supported by the National Science Foundation, achieves this by empowering learners with web pages designed based on key multimedia principles, including principle of contiguity, modality, redundancy and coherence.

Introduction

The development of the World Wide Web and powerful information technologies has redefined the concept of distance learning and the delivery of engineering education content. The new online BE3 degree is supported by the Alfred P. Sloan Foundation as part of its program in asynchronous learning network (ALN). Established in 1992, Sloan's ALN program has demonstrated that asynchronous learning is a dynamic and effective for anywhere, anytime education. As higher education teachers begin to integrate their traditional on-campus education with online distance e-learning, the development of engineering e-learning has been comparatively slow. Until recently, very few online engineering undergraduate degrees are available in the country. The likely reasons for this could be (1) the need in traditional engineering for hands-on undergraduate laboratories, (2) the traditional emphasis of mathematically skills, and (3) the lack of incentives for engineering faculty to get involve with the new online e-education pedagogy for the ID of online materials. In this paper, we describe an ALN course on Fundamentals of Nanotechnology as an elective for senior in the program. Since the BE3 degree are designed for students from SUNY's 64 institutions, as well as out-of-state and international students, the online program provides an opportunity to develop web based courses that will address some of the key issues for effective ALN engineering learning.

Problem-Based Learning (PBL)

A large fraction of students for the BE3 program is expected to come from SUNY's community colleges with vastly different experience, interest, motivation, and learning styles. They are generally more accustomed to the traditional passive classroom courses in which most of the course offering is standardized. The pedagogical model for the course incorporates elements of the problem-based learning (PBL) and multimedia learning (ML). The process of PBL is illustrated in Fig. 1 based on

Woods[2], who contrasted it with subject-based learning. PBL is chosen for the introductory course on nanotechnology because it's ideally suited to help students' development of new knowledge and skills.

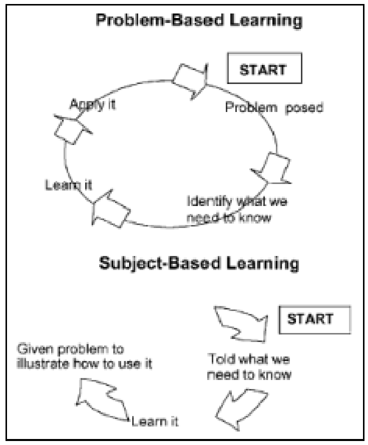

Figure 1: Problem-based Learning vs. Subject-based Learning

The principal ID ideas underpinning the pedagogical PBL and ML elements focus on the directed learner control in the ALN environment[3]. These ideas include (1) a clearly stated learning goal, which will be identified as the "problem" in PRL, (2) a readily available information resources for ML, and (3) adequate tools for the acquisition of knowledge and skills – i.e., knowledge and skill builders (KSBs).

PBL represents a major force in the web-based professional education. Many medical and engineering schools have created distance education curricula based on PBL. The elements of PBL used the development of the course include constructive, self-directed learner control, collaborative, and contextual learning. The constructive learning principle emphasizes that learning is an active process in which students actively construct and reconstruct their knowledge database. In the context of nanotechnology education, the course is designed to immerse students in the process of constructive learning process through solving nanotechnological problems.

Common Prior Knowledge Base

The first step in this process is to establish a threshold information basis for students of very different educational background. Using information available from the World Wide Web, student will start the learning of key components nanotechnology concepts from a multimedia site (Fig. 2). In the Molecular Electronics, for example, carbon nanotubes (CNTs) are introduced by referring to WIKIPEDIA page in which a multimedia explanation of CNTs is provided as follows:

Carbon nanotubes are cylindrical carbon molecules with novel properties that make them potentially useful in a wide variety of applications (e.g., nano-electronics, optics, materials applications, etc.). They exhibit extraordinary strength and unique electrical properties, and are efficient conductors of heat. Inorganic nanotubes have also been synthesized. A nanotube is a member of the fullerene structural family, which also includes buckyballs. Whereas buckyballs are spherical in shape, a nanotube is cylindrical.

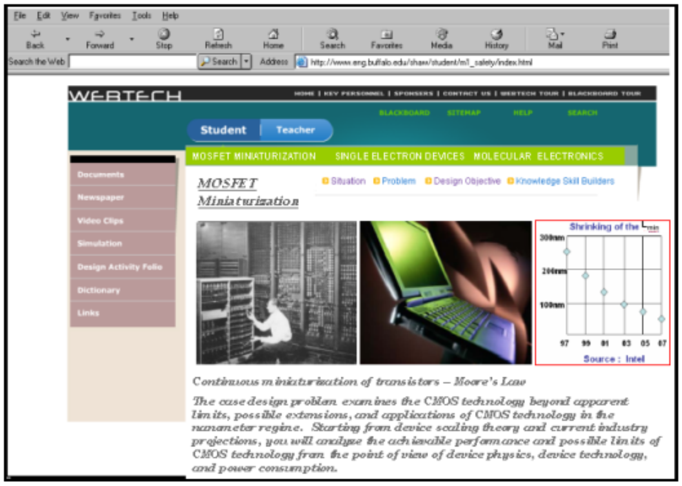

Figure 2: ALN Website

By using hyperlinks, students without prior knowledge will go to the linked materials to make up the necessary background materials required for the course, while students with prior knowledge will go quickly to the next topic.

Elaboration

The ALN learning adopted for the course is created for students to build personal interpretations of the nanotechnological world based on knowledge and skill builders (KSB) activities. Competence is fostered not primarily by lectures to deliver knowledge, but through interactive learning materials to stimulate specific kinds of cognitive activities.

Elaboration is an example of such an activity. Elaboration can take several forms, such as discussion, note-taking or answering questions. Elaborations play an important role in activating existing or prior knowledge structures.

The course is delivered to students using university's Blakboard.com[SM] e-learning system which is a powerful tool for elaboration and enhanced understanding of the new concepts. The course makes extensive use of the asynchronous collaborative tools available within the system, including the Discussion Boards, email, and Virtual Classroom. The Blakboard.com[SM] discussion boards contain forums and threads. Each forum, created by the teaching assistant, is a container for all the messages from the students that share an assigned discussion topic. Threads, on the other hand, are specific conversations consisting of multiple messages that address specific subtopics.

Directed Learner Control

(DLC) Students play an active in the planning, monitoring and evaluation their learning process. The course contents are divided into three folders containing the three topics (nanoelectronics, nanostructure materials, and nanobiotechnology), and students will receive the materials by logging into the campus-wide Blakboard.com[SM] using Adaptive Release. Students will start with the each folder for a limited period of time, or after users satisfactorily pass the predetermined required assessment tests. Each folder contains a link to a multimedia website with navigation tips to guide student's learning. The elements of PBL used in the course involve case-based reasoning whereby students are guided to solve nanotechnological problems under the guidance of the instructor.

Learning resources include twelve lectures (four for each folder) recorded live on campus and digitally encoded and mastered for Blackboard distribution. In addition, technical papers, appropriate websites, image galleries, practical experimental simulations are provided to students for just-in-time learning. Students are directed to used pre- and post tests for **self-assessment** and **planning** of their learning. Planning typically implies that a student starts with a folder, considers and sets the learning goals, takes the pretests, identifies the potential weakness in prior knowledge, and selects strategies for achieving the learning goals.

Monitoring

Monitoring implies that students are aware of the progress of their learning process at all time, and are in full control of the process. After completion, they take the post tests, and determine whether they are ready to move to the next learning subtopic. Small study groups (3-4 students) are formed at the beginning of the semester to facilitate interaction and partnership in learning. The group work together during the two-hour weekly sessions held during the semester. During the sessions, there is no didactic teaching since course lectures are provided on Blackboard's streaming videos. The professor acts as a facilitator of these discussion sessions, not a lecturer, and uses extensively the Virtual Classroom, emails, and Discussion Board as communication tools. Some discussion questions for forums and threads of the Discussion Board will be posted to induce reflection and elaboration. Reflection plays an important role in monitoring and self-regulation the SDL. Students are encouraged to air their problems, and to explain, elaborate and argue their points of views in the sessions. Self-regulation, which consists of both cognitive and motivational components, plays an important role in promoting and sustaining SDL.

Collaborative Learning

In the course, collaboration involves mutual interaction and a shared understanding of assigned activities. For example, one of the KSBs asks students to design a space elevator using carbon nanotubes (CNTs). As students organize themselves to investigate I) production of miles-long CNTs, ii) mechanical-strength requirements to support miles-high elevators, and iii) engineering design of anchoring such an elevator in space, share a common goal and responsibilities. They quickly learn that they are mutually dependent, and need to reach agreement through open interaction to complete the assignment. Factors within the collaborative learning situation that may enhance learning are elaborations, verbalizations, co- construction, mutual support and criticism and tuning in cognitively and socially. Students are also required to complete a class project on the conceptual design of a marketable nanotech-nological product. Students collaboratively present their project verbally at the end of the semester using university's EngjNet facility.

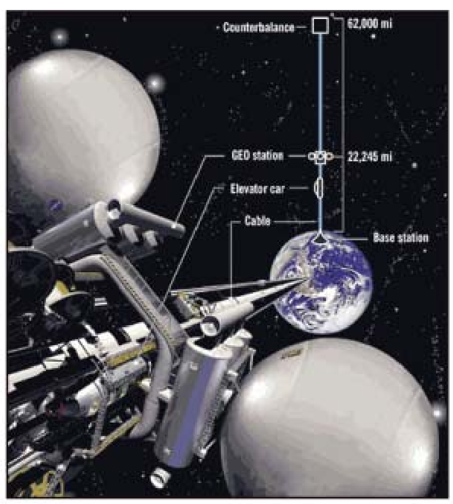

Figure 3: Carbon-nanotube Based Spaced Elevators

Multimedia Web Design Implications of an Integrated Learning Model

The pedagogical principles for the design of sound web-based instructional materials are guided by the work of Clark and Mayer[1]. Multimedia based courses typically involve the simultaneous use of visual (e.g., text, pictures. videos, animations, etc.) and auditory (e.g., narration, instructions, cues, music, etc.) formats.

Multimedia Principles.

According to the work of Clark and Mayer[1], simple rules are to be followed in the design of multimedia based course websites. These include: (1) Text should always be placed near graphics (contiguity principle), (2) text should be presented as auditory narration, rather than visual online test only (multimodality principle), (3) explaining graphics with simultaneous audio and text is redundant and can actually hurt learning (redundancy principle), and (4) spicing up e-learning with "bells and whistles" types of sound and pictures (i.e., gratuitous visual, text, and music unrelated to the learning topic) is harmful to learning (coherence principle).

Research in cognitive learning theory shows that we have two channels for processing information: visual and auditory, and our working memory has very limited capacity. When a learner sits in front of a computer screen and receives a multimedia presentation, words and pictures are presented (as indicated in the first column of (Fig. 4). Narrated words impinge on the learner's ears while printed words and pictures impinge on the learner's eyes (as indicated in the second column). Better transfer learning is realized when graphics are explained by audio alone rather by audio and text (redundancy principle).

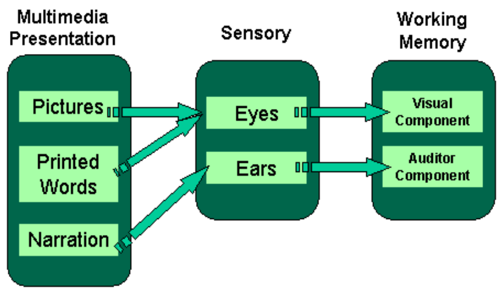

Figure 4: Presenting Words in Both Text and Audio Forms can Overload Working Memory in Presence of Graphics

There are exceptions to the redundancy principle, however, as recently reported by Moreno and Mayer[4]. In a comparison of a scientific explanation presented with narration alone and with narration and text, learning was significantly better in conditions that included both narration and text. The researchers conclude that, "An effective technique to promote broader learning with multimedia explanations is to use the auditory and visual modalities simultaneously for verbal information if *no other visual material is presented concurrently.*" Therefore there will be limited situations in which narration of on-screen text could be helpful to learning such as when there is no other graphic on the screen (coherence principle) or when students may lack good reading skills.

Summary

A new course, to be offered in the BE3 degree program, is designed based on a pedagogical model with elements of PBL and ML in an ALN environment. The nature of the program offers both a challenge and an opportunity to test the effectiveness of DLC, fostering a more individualized approach to engineering learning. The success of the approach depends critically on student's motivation for learning, skills in personal time-management, and ability to select relevant resources for the just-in-time learning.

References

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