AC 2012-3590: ACTIVE LEARNING FOR ENGINEERING/TECHNICAL GRAPHICS ONLINE ENVIRONMENTS

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Active Learning for Engineering/Technical Graphics Online Environments

Abstract

This paper will examine active learning concepts and active learning techniques that can be utilized for distance education and technology enhanced instruction. Some established online teaching and learning methods as well as strategies will also be discussed. Consideration of current online active learning environments will follow. Hybrid courses have been taught since Fall 2007 at North Carolina State University (NCSU) in Technology, Engineering and Design Education. In light of these courses, there is an interest in ways to improve operative instruction in these courses. This review of literature is the beginning step towards effective active learning strategies, processes, and procedures. In looking at the literature, limited information has been found on strategies to integrate active learning. The active learning strategies discussed will focus mainly on course content that can be utilized in engineering/technical graphics courses in higher education settings.

Introduction

"Schools exist to provide educational opportunities. Education should enable students to develop mentally, physically, morally, and aesthetically through the "experienced" curriculum"[1] [p. 650]. Formal instruction has two primary objectives[1]. First, cognitive development provides long-term acquisition and retention of stable and organized extensive bodies of knowledge and meaning. Second, is the growth in the ability to use that knowledge to solve problems, which provide solutions that further increase knowledge[1]. Unfortunately, cognitive development related to knowledge collection has been the primary focus of education in the past.

Active learning has been a topic of numerous papers and research since the 1970's and continues to be the focus of research and methodology discussions of instruction at all levels. The techniques of active learning are designed to move the focus of education from primarily knowledge acquisition to include the solution-based strategies that teach the "whole" student. Originally designed for face-to-face instruction, active learning now must be taken into the newer realm of on-line and technology enhanced learning. Figure 1 illustrates how active learning instruction may change the focus of teaching[1].

Today—Instructor Centered	Future—Learner Centered
Lecture	Facilitation
Student Listener	Collaborator
Individual	Team Learning
Instructor-Source	Instructor-Guide
Stable Content	Fast Pace
Homogeneity	Diversity
Testing and Evaluation	Performance/Assessment

Figure: 1 Learning Environments (Traditional vs. Active Learning)

Active Learning

Active Learning is "The process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas. Requiring students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline. The attainment of knowledge by participating or contributing. The process of keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving"[2] [p. 160].

Learning requires an individual to be active and engaged in the construction of one's own mental models, and, to do this, instruction needs to be moved from a teacher centric model to a student centric model, where students become part of the means of their own instruction. Active learning provides a number of different strategies to accomplish this and these techniques have been researched and have been shown to be effective means of instruction[2].

Literature on active learning generally includes the following characteristics:

- Students are involved in more than listening.
- Less emphasis is placed on transmitting information and more on developing students' skills.
- Students are involved in higher-order thinking (analysis, synthesis, evaluation).
- Students are engaged in activities (e.g. reading, discussing, writing).
- Greater emphasis is placed on students' exploration of their own attitudes and values[3] [p. 2].

Figure 2 displays a structure for active learning that shows how the elements of active learning students perform creates the building blocks of active learning strategies[4].

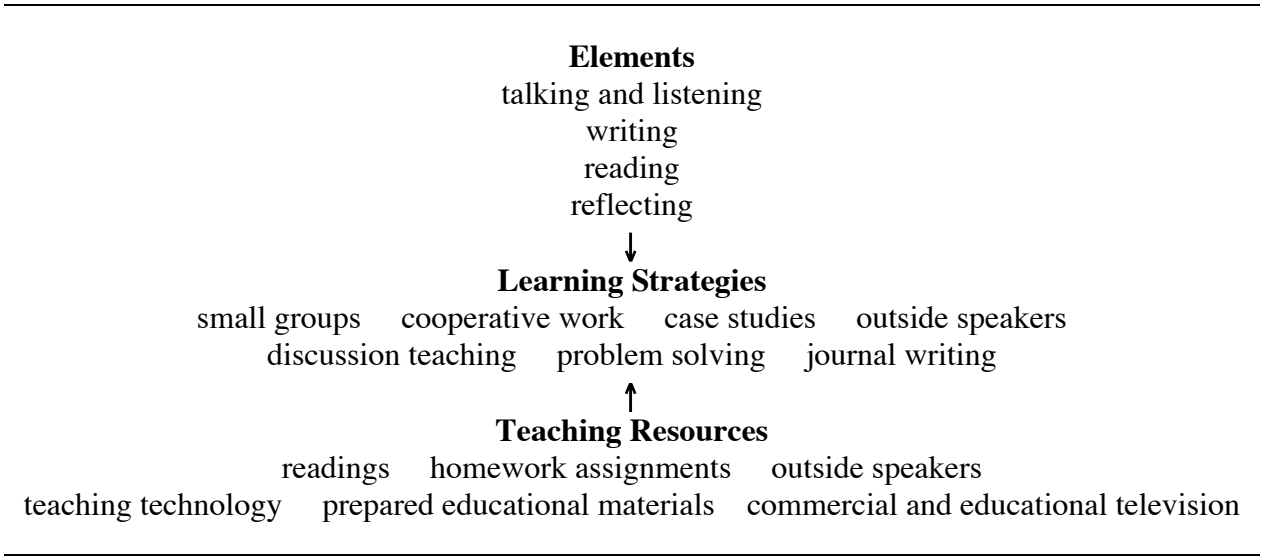

Figure 2: Structure of active learning.

With the advent of on-line and other forms of technology involved in teaching, active learning techniques are being adapted to this new form of instruction. These techniques can be applied to synchronous and asynchronous distance education frameworks. Successful face-to-face active learning practices and pedagogical approaches are readily appropriated for computer-supported cooperative learning environments and virtual classrooms, especially in the context of problem solving preparation[5]. For example, the anchored instruction model uses a video-based presentation scheme to introduce a problem. In solving the problem, "students must identify pertinent information and select among multiple solution paths" [6] [p. 20]. Jonassen further reports (from the Cognition and Technology Group at Vanderbilt) that anchored instruction requires elaborate problem solving. Students "must use the same skills and abilities required during realistic, outside-the-classroom problem-solving and decision-making activities as opposed to working the simplified, compartmentalized, and decontextualized problems common in traditional classrooms"[6] [p. 20].

Technology Tools in Instruction

Technology as part of teaching strategies can be argued is not new. Various types of technology has been part of instruction for years and included such well-known items as the overhead and slide projector. Visual aids, now an excepted practice in instruction was once a novelty. What is different is the type of technology, ways in which it can be accessed, the depth of information that can be obtained through it, and the ways in which individuals can interact through it[7].

Instructional technologies becoming part of instruction include distance education (synchronous and asynchronous), "clicker" systems for in-class instant feedback from students, on-line tutorials and exercises, email and chat room interactions, the use of the Internet for research and exploring topics, and electronic document sharing, to name a few. The devices that can be utilized for education also are shifting. Students and instructors have access to information and instruction not only from a desktop or laptop computer, but also digital tablets, smart phones, and dedicated readers. However, the form of delivery is not as important as the design of the instruction. Technology does not automatically improve instruction unless the instruction delivered through the technology is designed to be better. A number of studies have demonstrated that the technology alone does not improve students' learning and has no significant impact on student achievement. Researchers insist that these studies are asking the wrong question[8]. They state, "Learning occurs as a result of *motivation*, *opportunities*, *an active process*, *interaction with others*, and *the ability to transfer learning to a real-world situation*"[8] [p. 14]. The use of technology to achieve and expand these elements of learning is the real strength of the use of technology. It provides accessibility to people, data, situations and strategies that are not sometimes available as readily in a face-to-face instructional environment.

Distance education, for instance, as one of the "new" technologies in teaching, paired with active learning can be designed to move the center of the learning experience from the teacher to the student, where instructors become facilitators of learning and are no longer the center of the educational experience for students. Distance Learning (DL) is both a system and a process[1]. Its advantage is that it connects the learner with distributed resources, but it also can provide learning experiences to students. The process of DL is the way in which the distributed resources allow learners to learn.

Digital tools have been designed to allow individuals to gather an amount of data not normally possible but also to use that data to make decisions that enhance judgment by allowing more complex analysis of the data than normally possible. With technology we can easily get answers to questions that were difficult to obtain in the past because we can now look at data in unique ways. Even the variety of technologies, ranging from specific tools to more generalized devices on which this can be completed has increased[9]. "…while the need for wise people to discuss, define, compare, and evaluate perspectives is not changing, the means by which they do so and the quality of their efforts are growing more sophisticated because of digital technology"[9] [p. 3].

The use of and research on active learning techniques related to digital and distance education situations in the literature is limited. Most research relates directly with specific software and is limited in scope when found. In particular, there does not seem to be any research that links active learning to on-line graphics courses. However, the authors of this paper will suggest some activities that can be active learning based use of technology to improve student learning.

Characteristics of Today's Students

Students have adapted to multi-media forms of obtaining information and are much more capable of multitasking, which allow them to function well in the learning environment that includes technology-based instruction[1].

Today's student population has been referred to as digital natives who 'think and process information fundamentally differently'[9] from their predecessors and have been influenced dramatically by the technological shifts that have occurred within contemporary society[10]. The current generation of students is always on technology and can access information instantaneously. They do not rely on location or time to do this. Their expectations also differ based on the technology they have at their fingertips. Education, therefore, must evolve to meet the unconstrained expectations of students from this generation[10, 11].

As reported by Sontag, studies by Nisbett et al. (2001) found that the environment and culture in which people grow up actually affects their thought processes, and cognitive processes are more malleable than previously assumed. Magnetoenchalographic scans have found evidence that suggest that experiences rewire the brain, and that exposure to the Internet and other digital media shape how students receive information and learn as well as their preferences for how they receive information. This medium provides ways of performing experimental learning that match these expectations and can provide experiences that are not available in other ways[12].

The basis of instruction with the information age has moved from the 1950's center of cognitive theory of finite pieces of knowledge that was ready to learn to constructivist ideas. Constructivism is the construction of knowledge based on experience, which is better suited to a society where skills of networking, diversity, and group decision making is center on current needs of education and work environments[12]. Constructivist learning theory presents "meaning making" as the goal of learning processes (Figure 3). This goal "requires articulation and reflection on what we know"[6] [p. 11]. Students "tend toward teamwork, experiential activities . . . and the use of technology. Their strengths include multitasking, goal orientation, . . . and a collaborative style" ("2. Changes in Students," ¶1). Jonassen reports, "Collaboration, […], is the focus of constructivist distance learning activities (Seaton 1993)"[6] [p.13].

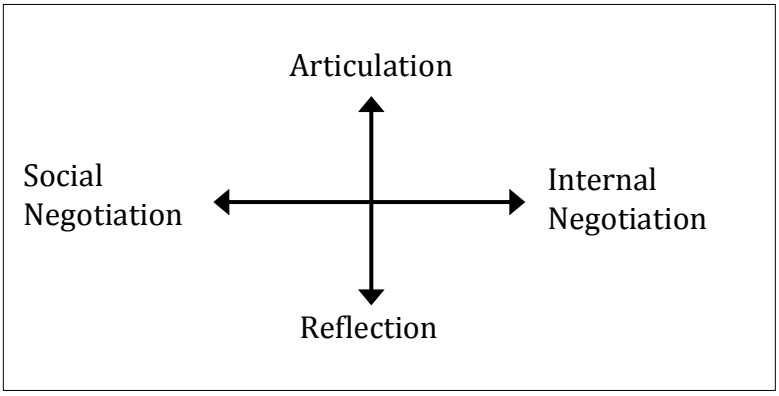

Figure 3. The Processes of Meaning Making[6] [p. 12].

Learning approaches are influenced by the teaching and learning environment, and strong teaching influences the quality of learning for students. Technology as an augment to instruction is ubiquitous in higher education and has influenced the retention of students when using a blended technological approach[13].

Buckley, et al. references Rae (2004) who reported that, by late 2003, student access to computers had risen to over 90%[14]. Goodyear et al. (2005) some specific technologically assisted-education activities have come to be called 'networked learning'. They define networked learning as: 'learning in which information and communications technology (ICT) is used to promote connections: between one learner and other learners; between learners and tutors; between a learning community and its learning resources'[15] [p. 473].

Cooperative and Collaborative Learning

Jigsaw

The Jigsaw strategy has been reported to be one of the most common and effective techniques of cooperative learning since its inception in the 1970's. A lesson may be divided into about five parts. An equal number of students form a group within which a group leader is selected. Each student in the group is then assigned one of the five pieces of the divided lesson. As students become familiar with their assigned material, those with like topics form new collaborative groups where discussions take place and each becomes an "expert" for their part of the lesson. Experts return to their original groups to peer-teach the material after which all students are quizzed on the topics of the day's lesson.

This technique has been successfully adapted to cooperative learning activities in the distance education environment via computer-supported groups[16], and using handhelds[17]. Specifically pertinent to this report, engineering educators have found Jigsaw activities to be positive and effective in online learning.

Soh's et al "research has designed and developed an infrastructure called the Intelligent Multiagent Infrastructure for Distributed Systems in Education (I-MINDS)"[18] [p. 1556]. Intelligent agents actively support two types of interactions: student-student and teacher-student.

Presently, three agents working together provide an effective computer-supported cooperative learning (CSCL) environment. Teacher agents distribute information streams to student agents. Student agents manage communication channels for the aforementioned interactions. "The group agent forms and conducts structured cooperative learning such as the Jigsaw model, monitors and facilitates group activities"[18] [p, 1557].

Instructors design tasks and subtasks, which students complete using Jigsaw techniques. Specific lab activities were assigned to a control group, students working in Jigsaw cooperative groups face-to-face, and a treatment group, those in groups communicating only from a distance using I-MINDS. The treatment group scored at least comparably to the control group. Findings indicate "that the instructor and the students can both use I-MINDS effectively as a framework for delivering distance education" synchronously and asynchronously[18] [p. 1563].

Developed by Stanford Research Institute International, *Group Scribbles* is a collaborative learning tool that allows users to generate, compile, and accumulate ideas in a common space. For Jigsaw activities, expert groups can copy any notes, or "scribbles," and paste them on the original group board to aid in final discussions. Lin, Liu, and Looi explored the use of Tablet PCs for collaborating activities in Group Scribbles. Upon completion of the Jigsaw activity, researchers noted scribbles, "which were created (and copied) from the expert group discussions, notes which were edited or re-created by others, and there are new notes"[19] [p.462]. Participants felt positive effects on their level of interaction, cooperation, and knowledge synthesis and integration; therefore, Group Scribble may be a promising, beneficial means for collaborative learning in distance learning environments.

A modification of the Jigsaw technique can involve the use of on-line tools where the "experts" from each group researches the information available on-line to create an integrated look at the area they should be experts on, compiled from individual research by the members of the expert panel. Then, with their collected information, they go back and teach it to the members of their original group.

Jigsaw can be used in graphics classes where students are learning broad concepts and detailed information, such as the variety of computer-aided drawing types as well as their strengths, weaknesses, and primary uses. One topic for this might be an activity on introductory modeling, meaning the use of parametric modeling principles based on standards for reading blueprints. Topic groups choose one particular drawing type: multiview-or axonometric. Next, rather than reading chapters in textbooks, listening to face-to-face instructor centered lectures, or watching live streaming, group members conduct on-line research and formulate the concept's essence. Experts then discuss their findings before peer teaching takes place. Each "lesson" is placed on-line for access by the entire class.

Think-Pair-Share

In think-pair-share exercises "students think about a problem, discuss it with their neighbors, and then share it with the rest of the class"[5]. They are encouraged to appreciate collective perspectives. Peer interaction is fundamental and provides immediate feedback. Timely feedback

is listed in the top 10 guidelines/practices instructors and students consider an imperative performance in e-Learning[20].

In an asynchronous medium (discussion groups, threaded discussions, blogs, wikis, learning management systems, etc.) relevant discourse, as in think-pair-share activities, can be directed[5]. Koppelman suggests a whole group be divided into sub-groups[5]. The smaller groups then work together in a closed discussion group for a pre-determined amount of time. At the end of time, publish the results and carry on whole group discourse.

Other methods and strategies

Studies reveal other exciting distance education technology enhanced methods and strategies: Games, simulations, and virtual worlds. Games are fun; simulations use rigorously structured scenarios; and virtual worlds are…persistent social environments[21]. All are realistic learning-by-doing situational opportunities. "Computer simulations open up myriad possibilities" for active learning experiences[22].

At NCSU, Branoff created a series of videos as part of the on-line teaching for *Foundations of Graphics* (GC 120), a course that provides instruction on the use of Solidworks [23]. Although this course is tightly packed, it does suggest an active learning strategy where students create a video of their own to demonstrate a particular technique used in this program. This would require the student or groups of students, to select an appropriate object or concept on which to create the video; write a script for dialogue to narrate, or teach; and then record it. These videos then could be part of a library of help files and lessons that are placed in a website or on a course management page for others to use.

According to Sontag, students in the 21st Century, which she refers to as the "connected" generation, are particularly interested in the connections between what they are taught and the application of that material, skill or concept to real world applications[12]. As a teaching strategy related to that, students can be asked research the use of a "modeled" item and analyze why certain aspects of the model is crucial to its use. This can become a more in depth assignment by asking them to relate aspects of mating parts, design intent, and quality control. This could be an on-line search as well as a visit to a manufacturer or user of the item, if appropriate.

Conclusion

The use of active learning is not limited to any specific instructional environment. It can be incorporated into both traditional as well as on-line and technology enhanced instruction. Software is now available to actually aid in the inclusion of active learning strategies in on-line instruction that have been demonstrated to be effective and efficient means of teaching the whole student. Students in our classrooms and in our distance education courses have different expectations than students in the past. They grew up with technology at their fingertips and are used to being able to obtain information anytime, anywhere, and on any subject. The quality of our instruction will be measured by these expectations.

Oblinger and Hawkins provide some interesting questions individuals should ask related to instruction provided through the variety of technologies now available and are worth contemplating when you design your own technological-based instructional strategies:

1. *Do we think of technology as a solution in itself or as a means to an end?* Technology does not always produce change if the pedagogical approach does not change with it. All things being equal, a piece of technology by itself cannot do the job.

2. *Do we assume that using technology is an either/or proposition?* One technology does not necessarily act as a replacement for another. Technologies used as part of instruction are more often combined when needed to accomplish instructional goals. This also implies that face-to-face instruction is appropriate as part of the mix when it does the job better.

3. *Have we identified those processes and activities we want to improve and looked at how technology can facilitate those actions?* With new technologies coming on, we should be looking not at the technology first but our instructional goals. Selecting the technology best suited to achieve that goal. Using a technology because it is the "latest" innovation should not be the impetus for its selection.

4. *Are we doing the same things with technology, or are we taking advantage of the unique capabilities of technology and redesigning our activities?* Technology provides us with such a diverse set of resources and strategies that were not available in the past, we should be redesigning instructions to take full advantage of these resources. To do the same thing using technology that we did in face-to-face only instruction limits our effectiveness and ignores opportunities we have to do a better job[8].

Since on-line and technology-based instruction is here to stay and is growing, we should examine ways to incorporate active learning strategies into this type of instruction, again where it meets the instructional objectives. In truth, many of us already include some elements of this but may not be aware that they are student centered learning techniques. Research that examines the effectiveness of these strategies on student achievement or satisfaction needs to be conducted. New strategies that are appropriate for our teaching field need to be created and examined. Technology gives us the tools, but we just have to grasp them and make them work for the benefit of our students.

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