

The Impact of Technology on Engineering and Computer Science Education in the 21st Century: Changing Classroom Instructional Methods

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Abstract — *The college instructor of the future will certainly have more technology available for use in the classroom. The decision to utilize instructional technology should be based on sound principals. The three guiding principals of using technology to enable, planning to support technology, and using technology judiciously are discussed in this paper.*

Index Terms — *classroom technology, computer technology, education, principals of use*

INTRODUCTION

At the university level, much of classroom instruction is provided by a lecturer standing in front of a group of students and delivering a monologue, while the students dutifully record essential parts of the information presented. Research and personal experience indicate that very little of the information delivered by the instructor is retained by the student when the student plays a passive role [4]. Computer technology offers some hope of changing traditional classroom instructional techniques, but technology alone will not turn college classrooms into Nurnberg Funnels [2]. This paper discusses the main issues with including technology in the classroom and presents some general guidelines for selecting and using technology in the classroom.

CLASSROOM ISSUES

Classroom technology includes technology that delivers instruction to students such as tutorial software and multimedia lectures; technology that students use such as calculators, spreadsheets, and word processors; and technology that instructors use to deliver content such as teleconferencing systems and presentation software. Examples of classroom technology include using computer projection systems for video and sound, teleconferencing systems for remote course delivery, audio systems for language instruction, simulation and tutorial software for student training, and computer-based visual presentations based on the World Wide Web.

The central issues to consider when deciding whether to incorporate technology in a course are the quality of the learning experience and the cost of delivering course content. The quality of the learning experience includes the amount and level of learning achieved by students. Obviously, if students do not learn the appropriate material

at an appropriate depth, the educational system is failing, whether or not technology is in use. In order for technology to be used in a widespread setting, it needs to be cost-effective. Costs include the time to prepare and deliver content as well as the equipment needed for the preparation and delivery.

One motivation for the use of technology in the classroom is to prepare students to meet the needs of employers. Most employers of college graduates expect computer literacy to be among the skills possessed by their new hires. Computer literacy is not just the ability to use a particular application program on a particular type of computer. It is essential for college students today to have fundamental skills that enable life-long learning and the ability to adapt as technology changes.

Another motivation for the use of technology is its adaptability. Research indicates that not all students have the same learning styles. It is desirable to utilize methods of instruction that match the learning styles of students in order to reach the greatest number of students. Tobias [8] identifies four styles of learning:

- learning by systematic approaches based on literal facts and routine;
- learning primarily by observation of experts;
- personalized learning motivated by personal relevance, general principles, and interaction with others; and
- learning based on insight, intuition, and experimentation.

Tobias states that students combine these styles, thus few students rely on a single learning style. Students learn most readily when the instructional techniques match their preferred learning style. Other authors have made similar observations [5]. Regardless of the learning style of the student, few students retain information without active involvement [4].

It is necessary to avoid the temptation to use technology to focus our students' studies too closely. Students should be encouraged to explore tangential ideas. Many of the difficult and interesting problems our students will face in the future will require knowledge, understanding, and appreciation for a wide range of fields. For example, civil engineers involved in water projects now must have some understanding of

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hydrology, geology, and environmental science in order to successfully resolve problems.

GUIDING PRINCIPLES

The decision to include technology in the classroom is complex. The principles discussed below can serve as a guide for determining how and when to use technology in the classroom.

Principal 1. Use technology to enable.

Technology should enable instruction that is not possible or practical without it. This is perhaps the essential issue in the use of instructional technology. At first glance, things such as multimedia presentations, animation, video clips, and fancy movement of text on screens appear to be more engaging than hand-written notes in chalk. The slides, sound, and animation make presentations more entertaining. However, when I observe students in classrooms where these techniques are used, they are no more engaged, and perhaps even less engaged, than students in the traditional lectures. The important fact remains that learning takes place when a student becomes involved with the content, not just the presentation.

Examples of enabling technology are tools that facilitate the management and manipulation of data. For example, calculators, word processors, spreadsheets, and databases allow instructors and students to focus effort on the underlying concepts behind the educational exercises as opposed to focusing on the mechanics. While it is true that students in mathematics courses who rely on calculators do not become as adept at arithmetic computations as students who practice these operations with pencil and paper, it is also true that greater effort can be placed on learning the appropriate use of computations in the context of problem solving. The appropriate use requires higher cognitive skills, is more difficult to learn, and is more important for the long-range success of the student. Thus tools such as calculators help our students acquire and demonstrate knowledge. Computation and communication tools should be included in classroom technology uses.

Technology can also provide access to information by assisting students with disabilities such as vision and hearing-impaired students as well as students who have difficulty writing and speaking. Other tools that provide access to information include email, the Internet, and library databases. Both instructors and students benefit from having immediate access to data available on-line. These technologies can provide access to real-world, multi-disciplinary problems and experts in the field.

Principal 1A. Use technology to improve communication.

Technology should encourage communication between students in a class, between students in different classes

(perhaps even at different institutions), between students and instructors, and between students and practitioners and experts outside the university setting. Instructors should also take advantage of expanded communication opportunities to expose themselves to good ideas presented by other instructors or practitioners. Additionally, communication technology can help disseminate information during the course. For example, on-line chat rooms help working students benefit from peer interaction, and email provides simple access to instructors when scheduling face-to-face meetings is difficult.

Principal 2. Plan to support the technology.

A major obstacle to the adoption of appropriate instructional technology is support. There are two primary issues. The first is that the technology does not do what the instructor wants. The second is the instructors may not know how to use the technology. The quality of much educational software is poor [6]. Frequently, good software requires more computer resources than available on inexpensive, low-end systems. The investigation of using educational software in the classroom should begin with an investigation of the software, then of computer hardware to support the software. Instructors and administrators must avoid the temptation to purchase computer systems first, then search for software. Too often, training and maintenance are neglected in budget estimates for technology purchases. When purchasing a technology system, it is necessary to consider all of the costs: hardware, software, training, technical support, and maintenance. Instructor time is also a limited resource.

Another often-neglected cost associated with technology in the classroom is the time that must be invested in training students to use the technology. For example, students using calculators in mathematics classes avoid spending the time and effort to manually perform the calculations, but they must spend the time and effort to learn how to use the calculators. This effort can be non-trivial and frustrating for students and instructors alike. Instructors must plan on teaching the use of the technology.

Principal 2A. Make technology accessible and allow students to integrate its use into their education.

Technology must be available to students at times and places that make it possible to integrate its use into their work. Not only do the facilities need to be available when students need them, the technology must be usable. Thus, software must be reliable, available, and user-friendly enough for students to use. Unavailable and unusable systems hinder, rather than enable, students. We should expect our students to utilize technological skills obtained in other courses, just as we expect engineering students to utilize mathematical skills learned in their freshman calculus courses.

Principal 2B. Teach students to critically evaluate information.

Ten years ago, when the central source of information for students was libraries, text books, and instructors, students could reasonably assume that the information to which they had access was reliable. The Internet has changed this. Students now have immediate access to enormous amounts of information, but it is no longer reasonable to assume that all the information is reliable [3]. It is essential that students are taught to critically evaluate the information to which they are exposed. They must be able to recognize the difference between glitz and substance. They must be able to evaluate the quality of the information they read. And we, as instructors, should not mistake visual appeal for substance ourselves.

Principal 3. Use technology judiciously.

Technology is not an end unto itself. It should be used to supplement instructor-lead teaching, not replace it. When evaluating the use of technology, Neil Postman [7] suggests considering the following questions.

- What problem does the technology solve?
- Who benefits from and who pays for the solution?
- What new problems will result from the adoption of a technological solution? Who may be harmed and who acquires power if the technology is adopted?

Instructors should be wary of technology that causes distractions. For example, email and the Internet facilitate communication and provide access to large amounts of information. But I have often observed students engaged in email conversations or web surfing in computer laboratories, to the complete exclusion of attention to the instructor.

The judicious use of technology also entails being familiar with its misuse. The vast interconnectedness and improved communication between students facilitates cheating. There are web services for finding “research” papers on almost any subject. Solutions to textbook problems and assignments are posted on readily available web sites. Faculty need to be aware of this and structure safeguards in assignments to guarantee individual student accountability. Plagerism is not new; what is new is that instructors can no longer assume that copying is not occurring in assignments were it was previously reasonable to make this assumption.

Principal 3A. Remember that ease of presentation is not the same as ease of assimilation.

Some technology is used primarily to facilitate the instructor’s job of presenting information. Presentation software greatly simplifies the display of notes during lecture, and it also simplifies the reuse and sharing of these notes between instructors. While it is initially time-consuming to create these slides on electronic media, once

created, they are relatively easy to modify. Thus, lecture notes in electronic format that are used from year to year may be updated more often than notes kept in other formats. The benefit is primarily for the instructor and not the student. Care must be taken to ensure that students are active and involved during presentations. This requires thought and time on behalf of the instructor.

When a lecturer moves from traditional lectures with notes hand-written on a board to a computer-based presentation system, it is possible to overload students with information. The inherent slowness of writing on a board limits the amount of material presented in a single lecture. Presentation software allows more information to be presented, but does not guarantee that students will be able to absorb the information. It is common for students to request paper copies of the slides, because they are unable to write quickly enough to keep up and feel uncomfortable asking the instructor to slow down during lecture. Providing these notes may lead to loss of attention during lectures, since the students no longer feel compelled to write notes themselves. A suggested solution is to hand out partial notes, so that students need not write everything, but are required to pay attention to fill in the gaps in their notes.

SUMMARY

Technology alone does not solve any of the difficult problems facing instructors. Teaching is hard work. Learning is hard work. Teachers need both teaching skill and subject mastery [1]. It is unlikely, at least for the foreseeable future, that human-led instruction will be replaced by purely technological systems. The need for qualified instructors remains. Technology is not a silver bullet, but it will appear in the classroom of the future. Instructors must carefully evaluate the costs and benefits before adopting instructional technology in their classrooms.

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