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Abstract

The use of computing technology in the classroom is becoming a de facto standard in the college classroom. Use of computers in the classroom is not limited to computer-related subjects, but has found widespread application in almost every discipline. Faculty and administration believe that smart classrooms provide a better learning environment for students. A survey instrument that was developed containing 30 questions covering three broad topic areas; instructor attributes and teaching experience, instructor access and technology use, and instructor perceptions of technology effectiveness. Our research indicates that successful use appears strongly related to faculty computer competence, time availability to both develop and maintain content, and the dependability of the technology on a day-to-day basis. While some instructors believe that smart classrooms may only add value to some subjects, most instructors believe that almost any course can be enhanced through the use of smart classroom technologies.

Introduction

The term "smart-classroom" encompasses a broad range of information technologies that are deployed in an educational setting. At one extreme is the "instructor workstation" coupled with a large display or projector used primarily for presentation. At the other extreme is the "hands-on laboratory" in which the instructor and each student have his or her own computer actively used during instructional time. The actual use of technology often varies significantly reflecting differences in subject matter, course content, and teaching style.

While little formal research has been completed that confirms the value of computer-facilitated instructional environments, there is a growing perception in higher education that smart classrooms have the potential to improve teaching and learning processes from both the instructor and student perspectives.

The purpose of this ongoing study is to investigate faculty experiences teaching varied subject matter using smart classrooms. It is felt that by collecting and comparing the experiences of faculty that have utilized computer technologies in the classroom, that patterns of successful use can be identified. It is hoped that these patterns can inform decisions regarding technology choices, course content development, and training / support for faculty and students.

Types of Smart Classrooms

For purposes of this research, a "Smart Classroom" is any classroom that explicitly uses computer technology to deliver educational content to students. Excluded from this definition are computer technologies not directly affecting course content, such as computer-controlled lighting, or which are proxies for traditional course delivery methods that do not affect the instructor's preparation or presentation such as video-teleconferencing. While most of the preexisting literature uses the general terms like "computer in the classroom" or "classroom computer", we identify three distinct categories of smart classroom; the "Instructor Workstation", the "Workgroup Laboratory", and the "Hands-on Laboratory".

The "Instructor Workstation" classroom is very much like a traditional classroom with individual student desks, whiteboards on the walls and an instructor lectern or table at the front. This is supplemented with a single computer, attached to a projector that the instructor manipulates to display what appears on the computer's monitor to the students. Often the computer is attached to a campus intranet and/or the Internet, and instructors will put course content on Internet web pages and use a web browser to display lecture content. This type of room can also be used to demonstrate the use of specialized computer software applications such as a graphics design tool, computer program development environment, or accounting software package.

The "Workgroup Laboratory" is a classroom with a small number of computers that groups of students share. Typically there is an instructor workstation at the front coupled to a projection device for demonstration purposes. The shared computers are placed on tables with chairs for four to six students. The student computers have large displays placed at the head of the table, and the keyboard and mouse have long cords so that the computer can be used from any position at the table. Usually the instructor has some kind of remote control that will allow him to change the image being projected from the instructor workstation to one of the student workstations. In this type of smart classroom, the instructor typically demonstrates some computer-related skill, and groups of students observe and then work together on a shared learning activity using their computer. This allows the instructor to walk around the room and provide feedback to the individual groups.

In the "Hands-on Laboratory", each student sits at an individual computer. The instructor will typically have a presentation workstation, and students will follow along with an instructor demonstration, or observe first then perform a classroom learning activity at their computer. This type of room is often used for computer-related skills development such as learning a course-specific software application or computer programming. This type of smart classroom can also be used for self-instruction via "computer-based training" type courses.

These three types of classrooms differ greatly in terms of content suitability, cost, and technical support requirements. In our initial survey questions, we do not differentiate between the three types of classrooms. We do recognize however, that content preparation is significantly affected by which type of room is being used, and our follow-on work will attempt to isolate factors relating to each type of classroom.

Background

The first experiments using computers in the classroom were conducted at Stanford University as early as the late 1960's (Peled 2000). In the 1970's large computers began to see significant use on college campuses, often through time-sharing agreements (Little 1973). In the early 1980's computer networks began to emerge as a significant part of the college campus communication infrastructure (Peled 2000). In the 1990's the Internet and World Wide Web became a campus institution, and towards the end of the 1990's, instructors began to use the Internet to deliver both assignments and course content (Peled 2000).

While the ubiquitous nature of Internet technologies makes it an excellent platform for distance learning, anecdotal evidence suggests that most college faculty are using the Internet to deliver content in face-to-face classroom environments rather than via distance learning (Rankin & Hoaas 2001).

Some research has suggested that multi-media presentations improve student learning. Kryder (1999) suggests that the successful integration of computers in the teaching environment results in students who are more "visually literate", are better at collaboration, and are better prepared to enter a technological workplace. Rankin and Hoaas (2001) suggest that the active learning that is facilitated by classroom technology are preferred by students because they "engage the greatest number of viewer senses". Marsh (1993) suggests that computers may lower learning barriers for disadvantaged students. Some researchers caution that not all subjects are suitable for "smart classroom" technologies (Raisinghani 2000). Kent and McNergney (1999) note the failure of earlier technical innovations such as television, tape recordings and video to significantly change the teaching paradigm, and at least one experimental study did not find that learning outcomes were improved through the use of multimedia presentations (Rankin & Hoaas 2001).

Some of the challenges that have been identified in deploying and using smart classrooms include fear of the technologies (Raisinghani 2000), lack of training and / or technical support (Kryder 1999), or unsuitability of subject matter to the use of a particular technology (Raisinghani 2000).

One factor that possibly affects smart-classroom success is the "computer literacy" of students. Computer literacy in this context refers to a student's skills relating to keyboarding, system operation, and use of common software applications like word

processing, e-mail, Internet browser etc. (Lockard & Abrams 2001). While admittedly an important factor in some smart-classroom settings, this research will focus primarily on instructor-related issues; the effect of pre-existing student computer literacy on learning outcomes will be, for the most part, treated tangentially.

Relevant Literature

From the first introduction of computers into the classroom in the mid-1970's, educators have in various degrees attempted to add value to educational content and delivery mechanism through their use. In more recent years, institutions of higher education have made significant investments in computer-based technologies, most notably in the creation of computer supported classrooms and laboratories (Anon. 2000), (Natalicio 2000). Clearly, information technologies have become such a dominant feature of college student life that student dormitories, lounges and libraries have been almost universally wired to provide 24hr access to the campus network and the Internet (Flynn & Kamm 1999). There is a perception among faculty and administration that making computers, multimedia, and Internet-related technologies an integral part of the learning environment has the potential to both improve the quality of the learning experience and possibly deliver course content to either a larger or more distributed student population without loss of quality or increase in cost.

The earliest use of computers in education has been mostly by students in the preparation of assignments, i.e. writing papers, spreadsheets, presentations, etc. An emerging paradigm in higher education seems to be more focused on the delivery of course content through the real-time use of computer technology in the formal classroom setting. While a significant amount of research exists documenting success factors relating to the use of technology in distance-learning scenarios, little has been done that examines the real-time use of computers by instructors in the classroom. This research attempts to discover how university instructors are using smart classroom technologies, and identify the concomitant challenges and successes, and the factors contributing to both. The goal of this research is to identify the patterns of successful use of smart classrooms in order to inform decisions regarding classroom technology choices, the development of course content, and the degree of training and support needed for faculty and students.

Theoretical Framework

This research is based on theories relating to adoption of innovation and technology acceptance. While faculty are seemingly under some organizational pressure to use smart classrooms, it appears that the decision to use technology is generally an individual one. We therefore are dependent on the large body of work relating to individual acceptance of technology. Agarwal (2000) suggests that there is a relationship between individual acceptance of technology and the anticipation of certain individual-level outcomes. These outcomes include "improved work performance, enhanced productivity and user-satisfaction". These outcomes are posited by Agarwal to be "first-order" effects that eventually promote increased competitiveness and profitability at the organizational level.

There appears to be some indication that organizational-level interest in smart classroom adoption and use relates to an expectation of second-order benefits. However, our research on smart classrooms is focused on evaluating how the anticipation and realization of the first-order benefits influence the adoption and use of smart classrooms by individual faculty members.

Fishman (2000) states that many IT adoption decisions are made in two stages. In the first stage, the organization makes a formal decision to adopt a technology. In the second stage, individuals and small organizations (departments) then make a "local" decision to adopt. This model of adoption seems appropriate to the college setting where administration will authorize (fund) the investment in classroom technology, thereby making the technology "available", followed by instructors and possibly departments making a separate decision to use the technology in the development of course content. Fishman suggests the use of adaptive structuration theory (AST) (DeSanctis & Poole 1994) for research relating to two-stage decision technology adoptions, since it provides a structure that allows for richer explanations of interorganizational innovation processes. Some of the design elements of AST research include:

- Use of measures that capture varied differences in post-adoption outcomes
- Examination of factors affecting individual technology acceptance
- Focus of attention on elements that have a very large influence on latter stages of assimilation

The exploratory research introduced in this paper reflects elements in each of the above areas. Future research will be designed to more fully capture the beliefs, motivations, and expectations of smart classroom users in a way that can be formally evaluated in terms of adaptive structuration theory.

Research Methodology

In this initial research phase, a review of prior research suggests that a survey approach would be appropriate (Fraenkel & Wallen 1996), (Arbaugh 2000). A cross-sectional survey attempts to take a snapshot of the domain at a fixed-point in time. Since the goal of this research is to collect experiential data in the context of its perceived value at the present time, then the use of a cross-sectional approach is deemed appropriate.

The survey instrument that was developed contained 30 questions covering three broad topic areas; instructor attributes and teaching experience, instructor access and technology use, and instructor perceptions of technology effectiveness. Approximately half the questions were subjective; the others were more open-ended allowing the interviewee to offer richer experiential answers. The survey was designed to be used in an interview setting.

Data Collection

In the pilot phase of this research nine interviews were conducted with faculty members from the College of Business at California Polytechnic University of Pomona and the College of Arts and Letters at the University of La Verne. The interviews followed a script that sought to determine experience level teaching in the smart classroom, experience with technology, satisfaction with smart classroom experiences and effectiveness and efficiency issues related to smart classrooms. Table 1 shows demographic data about the faculty interviewed for this study.

Table 1. Faculty Demographics for Smart Classroom Interviews

Degree		Gender		Rank		Teaching Exp		Smart Class Exp	
PhD:	6	M:	6	Full:	4	0-5yrs:	0	0-5yrs:	0
M:	3	F:	3	Assoc:	2	6-10yrs:	2	6-10yrs:	2
				Assist:	1	11-15yrs:	3	11-15yrs:	3
				Adjunct:	2	20 +yrs:	4	20 +yrs:	4

Table 2. Indicators of Faculty Use of Technology

Faculty Member has Course Web Page: Yes: 7, No: 2
Use of Power Point Presentations in Lectures: Yes: 6 No: 1 Sometimes: 2
Use of Email to Communicate with Students: Yes: 9 No: 0
Reported Number of Email/week: average=125 , sd=236 (lowest=10 highest=750)
Faculty Member has/maintains own Server: Yes: 3 No: 6

Analysis/Discussion

The following discussion addresses the research findings by survey question.

Faculty Training

Faculty reported overwhelmingly being self-taught in the use of technology. On average, faculty reported having 10% of their training in technology delivered formally, and the other 90% being self-taught. This is interesting in that faculty, being creative and investigative in nature, have already been very successful learning and investigating independently. Indeed, this is the work of scholarship. However, it is also problematic in that a large effort and expenditure is being made to "improve faculty use of technology in the classroom." It is common that campuses offer workshops for faculty to learn new technological skills. The workshops may fall short in two ways. First, they do not address discipline specific use of technology in the classroom. Second, faculty need to actively attend a workshop, when their learning might be better facilitated in contextual setting. Lack of training is not necessarily the barrier to using technology in the classroom. A greater barrier is lack of time. Incentives of release time would enable faculty to self-train and effectively use technology in their courses.

Evolving Teaching Style

Teaching in the smart classroom has in some cases had a major impact in the way a course is presented. Even in a traditionally "non-technological" course such as accounting, the smart classroom can have a profound affect on the learning process. As one interviewee stated: "It used to be that [the students] did homework assignments at home and came to school to listen to the lecture. Now they read cases and material at home and come to the classroom to do the homework". Several participants shared the perspective that they spend less class time lecturing and more time demonstrating and sharing live examples.

Class Preparation

Responses to this question varied widely between the respondents. Some participants expressed feelings that smart classrooms saved them time due to easier reuse of instructional materials. One didn't think it made much difference. Several felt that using a smart classroom actually required more preparation time, but that the results justified the additional effort.

For some instructors, preparation goes beyond just reading and writing lecture notes or preparing a "slide" for presentation. Many instructors also report having to prepare data files for use with specialized computer programs. In order to use these files, instructors are "uploading" files to either personal or shared "servers". This implies knowledge of computer technology far beyond the use of a word processor and saving a file on a diskette. It should again be noted that these instructors largely reported that they were self-taught.

There appears to be a technology "trap" relating to the use of technology in the classroom. Once someone has bought in to the notion of using a smart classroom, there seems to be an unspoken imperative to "stay current" with the latest software, materials and techniques. This may be more related to just the nature of living in a world of light-speed communication, but access to a smart classroom seems to eliminate some the reasons to resist this imperative.

Added Value to Student Learning

A majority of the respondents indicated their belief that students were learning "better" in the smart classroom. One instructor remarked, "I think they are better off, not happier. They [may not like taking an exam on the computer] but they are much better prepared for industry".

While most instructors seem optimistic that smart classrooms improve learning, some express concerns that students accept less personal responsibility for learning outcomes when most of the course content is handed to them. One participant stated, "Students are lazier. They have no pressure to attend class. They know that the lecture is on the web, and that they can download everything from the lecture up to the assignments, so they are less and less interested in meeting with the professor and other students".

More positively, another participant noted that students are able to collaborate in real time on projects better: "It was great to be able to bring [database] students together at each [workstation] so they could form informal teams and work collaboratively [with hands-on applications]."

It is interesting to note that one of the respondents indicated that once students have been exposed to the smart classroom environment, it becomes the norm and they begin to "demand" it in all their courses. A class delivered in a traditional setting is not perceived as having the same value.

This same respondent also observed that it is not only the students' expectation that have been raised through the use of computer technology in the classroom. Faculty have also raise their expectations of students. With the easy accessibility of computers, many faculty no longer accept hand-written assignments, even if they contain charts, graphs, or diagrams. "My computer crashed" is not accepted as an excuse for turning in late work since friends, family, and campus computer labs are all felt to be easily accessible to provide basic computing resources. The risk of a last minute computer failure is known to exist, and many instructors warn students to make back-up copies and not wait until the last minute so that they have time to recover from the occasional computer problem.

Added Value to Teaching Effectiveness

The faculty that were interviewed seem evenly divided when ask if students were actually learning more in smart classroom settings. Three respondents didn't think so, three were unsure, and three thought that students were learning more. One participant liked the fact that students were able to get immediate feedback in computerized class settings, which allowed the instructor to increase the complexity of assignments and class problems.

Successes and Obstacles

The greatest single problem reported by users of smart classrooms was arriving at the class and finding that the computer or network was not working. This situation seemed particularly prevalent in shared classrooms 3 – 5 years ago. One respondent described a situation where due to a lack of space on the classroom computer hard drive, other faculty would uninstall applications on the classroom computers in order to make room for their own applications. If an instructor had a special application on the classroom computer, there was a good chance it wouldn't be there the next time. Another respondent noted that "there was no teaching support…everybody changed the settings of the equipment [all the time]". As universities gain more experience, it appears that control of classroom environments is much more rigid; some flexibility has been sacrificed in favor of maximum availability for all users.

Another obstacle facing potential users of smart classrooms is the time required to learn how to use the technology. This time investment is not limited to the person learning about the classroom, typically the training is provided by a colleague rather than in a formal training environment.

Even after the instructor has learned to use the technology, instructional materials have to be prepared. In the smart classroom, there is little opportunity to "wing it" or lecture "by the seat of your pants". Everything has to be prepared in advance.

There is an assumption by many instructors that students are experienced with the use technology in the classroom and at home. Many university programs require students to pass a computer competency course; however, the degree of actual skill possessed by students varies widely, with students from disadvantaged backgrounds having the least pre-college computer experience. While many faculty believe that college students can reasonably be expected to have access to a personal computer outside of the classroom, it is often cost prohibitive to provide students with specialized software often used in upper-division courses. Students and faculty become dependent on the classroom in order to complete assignments, and when students and faculty become dependent on the technology, a high degree of frustration is experienced when things do not work.

Most respondents felt that the greatest success from the use of the smart classroom was the ability to provide "hands-on" experience with "real-world" problems and tools in the classroom. In the traditional classroom, the theory was removed from the practical; students had to apply the theory outside of class without the instructor being immediately present. Smart classrooms are felt to provide a similar experience to a broader range of subjects as those provided by the traditional "lab" classes offered in the "hard" science programs.

When Not to Use the Smart Classroom

Most faculty answered this question in the context of their current instructional assignments rather than speculating on courses that in theory might not apply. This resulted in a high percentage of null responses where the faculty could not think of a course

that would not be appropriate for the smart classroom environment. One participant suggested, "even if there are no [software] tools [being taught], you would need the smart classroom for collaboration and discussion and group support".

Another respondent indicated that a research methods course would be inappropriate because "dialog is really important in this class. [Students] use computers to find information and do research, but the crucial part of the class is about ideas and discussion of ideas". Another respondent hypothesized that English or Math courses might not benefit from use of a smart classroom environment.

Faculty Productivity

One of the most important impacts that smart classrooms have appears to relate to the ability of instructors to share instructional materials with their colleagues. Generally, instructional content that has been designed for the smart classroom environment is in some kind of "electronic" form that can be processed and displayed via computer. Materials that are in an electronic format can be infinitely duplicated and shared with little effort. While some respondents did not use materials developed by other instructors, most reported a significant amount of content developed by others, especially when preparing to teach a "new prep" course for the first time. This "fast start" not only shortens the time for preparing to teach a new subject, but also promotes uniformity when two or more different instructors teach a course.

Most respondents mentioned productivity benefits relating to the ease of maintenance of electronic course materials. Revising and updating instructional materials that have been prepared electronically is a relatively straightforward task and does not require that the entire document be retyped. Courses that are taught frequently may only need minor administrative changes relating to dates, times, room numbers, etc. This benefit not only applies to the typical updating that occurs prior to the commencement of a course, but is even more valuable for mid-term revisions. Materials that are centrally available from a course web site or server need only be updated in one place. Distribution is as simple as sending an email notice to the members of the class.

It is apparent that despite the extra work involved using the smart classrooms, a majority of the faculty using them feel it improves the educational process. The extra time commitment required cannot be explained by a mere obsession with gadgetry. The reason for this seems to be that by improving the delivery mechanism, teaching is focusing more on concept integration rather than cognition; learning is focused less on memorization and more on comprehension and integration.

Prescriptions for Success

In this exploratory study, several patterns for success seem to have emerged:

- Faculty computer competence, both in the use of hardware and a broad variety of software tools appear to strongly influence perceived usefulness. In practice, a faculty member will develop their content out of the classroom. Any software tools available in the classroom must also be made available to the faculty member on their home or office computer as well.

- While almost any course can be improved by the use of smart classroom presentation technologies, courses that have a strong visual component coupled with kinesthetic skill development are particular suited to smart classroom use. Computer-Aided Design software training and computer programming courses are examples.

- High reliability "uptime" is essential for smart classroom use. Faculty must be able to trust that the equipment will work when the class starts. As a general rule, materials prepared especially for the smart classroom can't be used in a traditional classroom setting without some prior preparation. In that case, if the room is down when the teacher arrives, the class is over before it starts. High reliability is not an accident; rather, it is a result of competent network and computer management by trained and skilled technical staff.

- Contingency preparation is a must. Despite every effort to prevent system outages, problems do occur. Faculty need to have a back-up plan for any class situation heavily dependent on technology.

Directions for Future Research

This exploratory study has revealed a number of possible avenues of research. Our next step will be to improve our survey instrument to better isolate classroom use from support technologies used outside of the classroom. This revised instrument will

then be administered to a larger sample group in the order of 40-50 individuals. It is hoped that this larger sample will provide stronger statistical indicators relating to the study.

Other areas of possible research would be to survey student perception of the smart classroom environment. While it may be difficult to get "before" and "after" measurements, not all courses are taught in smart classrooms, so students could compare and contrast their experiences in several classroom environments, and across different disciplines.

Another area of possible exploration relates to faculty use of support technologies. Many of the interviewees who use smart classrooms also appear to concurrently be using computer technologies outside of the classroom, and their answers often applied to the combined use of these technologies. These "support technologies" include e-mail, faculty-owned Internet web pages, class-specific discussion boards, and formal on-line class "communities" such as "Blackboard". These support tools are often associated with the smart classroom, because the instructor will "post" or "upload" their materials for use in the classroom, and at the same time give the students access to the materials for printing copies of the presentations and/or assignments. Discussion boards allow the students to publicly post questions relating to course assignments and receive answers either from the instructor or from other students in the classroom. The use of these support tools requires a significant amount of instructor time, and modification of the survey instrument is probably advisable in order to isolate the impact of just smart classroom use.

Finally, more and more students are using personally owned notebook computers in college. This in certain ways makes every classroom that they attend a "smart classroom", depending on the nature of the course content. The formal integration of notebook computers with electronic course content might have a similar impact as the formal smart classroom and has to the potential to produce interesting results.

Conclusion

The use of computing technology in the classroom is becoming a de facto standard in the college classroom. Use of computers in the classroom is not limited to computer-related subjects, but has found widespread application in almost every discipline. Faculty and administration believe that smart classrooms provide a better learning environment for students. The greatest perceived benefits are derived from "hands-on" learning rather than from multimedia-enhanced lectures. Some concerns have been raised about over-dependence on technology by students who become "lazy" and expect to have all course learning content available 24 hours a day at the click of a mouse button.

Generally, faculty are optimistic about the benefits, but largely agree that it takes more work to prepare and maintain content than in a traditional setting. Some productivity gains are reported resulting from ease of maintenance of electronic course content and from sharing of course materials between instructors. At present, most faculty users are self-taught in the use of classroom technology.

A primary concern relates to the availability and support of the technology. Most participants related "horror" stories of their first use of smart classrooms, but nearly all admit that controls are now tighter and support and availability is much better than in prior years.

Successful use appears strongly related to faculty computer competence, time availability to both develop and maintain content, and the dependability of the technology on a day-to-day basis. While some instructors believe that smart classrooms may only add value to some subjects, most instructors who are users believe that almost any course can be enhanced through the use of smart classroom technologies.

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