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COST-EFFECTIVENESS OF THE INTELLIGENT CLASSROOM FOR INFORMATION SYSTEMS INSTRUCTION

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ABSTRACT

An intelligent classroom has been put into use for information systems instruction. It features 35 student workstations in a networked, multi-media classroom with interactive, application and activity control software. Capabilities of the intelligent classroom are reviewed, modes of instruction and their marginal cost are described, and a comprehensive cost effectiveness assessment methodology for this learning/teaching configuration is discussed. Preliminary assessment results are quite encouraging. Should the full evaluation bear out the preliminary results, then a quantum jump in educational effectiveness will have been demonstrated. This should act as a catalyst for nationwide implementation of the intelligent classroom.

Keywords:: intelligent classroom; multi-media; interactive instruction; information systems instruction; instructional cost effectiveness evaluation; interactive classroom.

INTRODUCTION

After passing through the Industrial Age and the Information Age, the next stage is the Intelligence Age according to Watson [5]. One manifestation of this is the advent of the intelligent classroom. Variants of intelligent classrooms are in use, among others, at the following universities: McGill, Northwestern, Chicago, MIT, California and California State. An intelligent classroom for IS instruction was put into use at California State University, Dominguez Hills in September of 2002. This educational facility is described herein, its capabilities are delineated, modes of instruction and their marginal cost are discussed, a comprehensive cost effectiveness assessment methodology for the intelligent classroom is outlined and some preliminary assessment results are presented.

In the implementation at California State University, Dominguez Hills, there are 35 student workstations with flat screens, housed in modern carrels, networked to a server and a printer by means of cabling and a communications switch. The latter also serves to connect the classroom to the Campus backbone network and the Internet. The instructor uses the server, which also can function as a multi-media machine that displays its output on a large screen in front of the room. Imperata, an application and activity control software system, is installed on all the student machines and on the instructor's server. The physical room originally was a regular classroom which had sufficient air conditioning and electrical capacity to support the configuration that was installed.

CAPABILITIES OF THE INTELLIGENT CLASSROOM

Intelligent classrooms combine the capabilities of multimedia classrooms, computer laboratory facilities, network infrastructure, and an instructional activity control software system. Multimedia classrooms have the capability to display on a screen at the front of the classroom what the instructor is doing on his or her computer, as well as to display material from a VCR and from a drawing pad. Computer laboratory facilities provide a computer for every student and the appropriate furniture to house the computers and monitors. Network infrastructure provides interconnection, remote printing capability and access to the Internet. This requires cabling in the classroom and switching hardware that is linked to the campus backbone Internet connection. With an interconnected computer for every student, the software activity control system allows for automated interaction between teacher and students, online training, computerized interaction between students, presentation capability from the instructor's console or any student machine and a host of other learning and teaching enhancements.

The intelligent classroom presents the instructor with a variety of options. In the sphere of classroom control, the instructor is able to shut down, lock, message and view any student computer screen. Such capabilities aid in maintaining classroom discipline. With regard to instruction, the teacher can share his or her computer screen by making it appear on any or all of the students' monitors. Then, by lecturing and simultaneously moving the computer cursor, the instructor can undertake various content explanations. This mode of instruction, according to student reactions, is preferred over having the material projected on a large screen in front of the classroom, as is done in standard multimedia rooms. However, both modes are still passive as far as the student is concerned because the contents of the instructor's screen are not interactively accessible to the students.

The above state of affairs can be improved upon in the intelligent classroom by the additional capability of having the instructor's screen appear in split screen mode on the students' machines. Under these circumstances, the students can bring up on their computers the same software the instructor is using, and the two versions of the same software would then appear side by side. The students still cannot interact with the instructor's half of the screen, but they can duplicate any actions taken by the instructor using their own installed software. This permits practically simultaneous execution of commands and provides hands-on learning as opposed to note-taking with hands-on practice coming later. Any problems that arise can be attended to immediately, which can save countless hours for the less skilled students. Also, it enables class-wide display of difficult problems and their solutions so that individual students do not repeat the same errors multiple times. Needless to say, this capability lends itself well to teaching the various functions of a software package.

Another instruction-related feature is that of collaboration or interaction between the instructor and a particular student. As students are doing work, the instructor can view what they are doing and can make suggestions via messaging and also by remotely accessing the screen of the student's computer and actually making changes and corrections. This may be looked upon as one-on-one interactive instruction. Furthermore, all that has been described so far can also be displayed to all of the other students on their screens. This sharing can help to point out potential errors to other students before the fact. This can even be taken a step further if the instructor allows interaction on a given student's screen by other students.

The capacity to share a specific student screen with the rest of the class lends itself to the making of student presentations, and the collaboration feature allows the instructor to assist and correct the student who is making the presentation. To perform the presentation, the student would bring in the material on a removable disk. For example, such material could be a backup of work done outside the classroom that is then restored on the student computer in the classroom. The student makes the presentation from his or her seat, and the material is made visible on all other computer screens in the classroom. The instructor can make or suggest corrections, and the student can implement them in real time. Saving the corrected material to the removable disk allows the student to have a corrected version for later use. Finally, permitting one or more of students to interact on another student's computer enables presentations by teams.

During a presentation, the non-presenting students do not have direct access to the work of the presenting student on their own computers because they see it via the activity control software. However, if the other students wish to make a copy of the presenting student's work, then they can gain access to it from a central shared area on the instructor's server. The presenting student simply copies his or her work to that area, and the other students then copy it to their own machines. From there, they would copy it to removable media. This represents a major improvement over the conventional note-taking process. An underlying assumption is that the same application software that is used in the intelligent classroom is also available to the students elsewhere. In other words, work done in the intelligent classroom should be able to be transported to other locations on disk, with backup and restore functions being performed at both sites. In addition, the intelligent classroom contains a shared printer, so that material can be printed and distributed.

To be effective, the various capabilities described above need to be employed in a manner based on a cohesive teaching methodology for each particular class and body of subject matter. It should be noted that each individual capability of the intelligent classroom is just that—a capability. It is the integration of these capabilities to make course material more easily understandable to students that brings the uniqueness to the intelligent classroom as implemented at California State University, Dominguez Hills. The room has been used to teach a number of IS courses, but the main emphasis has been on an advanced systems development course wherein every student is responsible for doing a real world systems development project based on problems encountered at their current or previous places of employment. It is in this context that the various capabilities described in this Section have been developed, honed and applied. The way the capabilities of the Imperata system have been utilized in conjunction with the CASE software that is used in the course represents a quantum jump in instructional effectiveness. The reaction of students and faculty has been thoroughly favorable, and this is further discussed in the Preliminary Results and Conclusion section of this paper.

MODES OF INSTRUCTION AND THEIR MARGINAL COST

Information systems can be taught in a variety of settings including lecture, lab and lecture plus lab. The lecture setting can be done in an ordinary classroom, which may be regarded as the "basic" mode. It is assumed that such a classroom is provided by the University. Other things that need to be considered is whether appropriate electrical power, air conditioning and security is available in the classroom. If these are not available in the appropriate configuration for the classroom equipment, then there would be additions to the cost figures given below. Described below are four increments in capability to the basic mode, each of which builds on top of the previous.

A first increment of capability to the basic mode comes in the form of multi-media (i.e., the capacity to display on a large screen what the instructor is doing on his/her computer as well as the ability to display material from a VCR and from a drawing pad). The cost of the multi-media capability including a secure furniture podium and instructor's computer is on the order of $20,000 to $25,000, including wiring and installation.

A second increment of capability comes from having a lab setting in the classroom. This requires that there be a computer for every student with appropriate furniture to house same. The cost of this, assuming a computer configuration such as that described for the intelligent classroom at CSUDH, is about $1500 per student seat or about $50,000 for a classroom with capacity of 35. The addition of this capability allows the class to be taught in either lab or lecture mode at any time in accordance with the desires of the instructor.

A third increment of capability is local networking and access to the Internet. This requires cabling in the classroom and a switch which is connected to the Campus backbone. Once you have the cabling, then it becomes feasible to add a printer and/or other devices which are accessible to all computers in the room. This will cost about $15,000 for a classroom of capacity 35. Wireless is an alternative but would have a different cost structure. Existence is assumed of a Campus backbone network that will provide Internet access for the classroom. Should this not be the case, then extra costs will be involved.

A fourth increment of capability consists of making the entire classroom "interactive" by means of an activity control software such as Imperata. The server side of such software is installed on the instructor's machine, and the client side of such software is installed on the student machines. This requires that the instructor's computer also act as the Imperata server and thus necessitates a more powerful machine than might otherwise be required. The marginal cost of such hardware and software is about $10,000 for a classroom with capacity of 35. It is after the addition of all four increments of capability that the intelligent classroom has the infrastructure that it requires.

COST-EFFECTIVENESS EVALUATION OF THE INTELLIGENT CLASSROOM

The cumulative cost of all four increments of capability described in the previous Section would be on the order of $100,000. The classroom could be used to teach 20 to 25 three unit classes per week on a semester basis. Total school year utilization could amount to between 50 and 75 courses. This implies that at least 200 courses could be taught in the facility before replacement issues arise. Thus, the estimated cost per course would be $500 per course. Amortized over 25 students per course, this comes to $20 per student and would represent a 2.5% increase in tuition for an $800 course.

The effectiveness of the intelligent classroom may manifest itself in (1) concepts and material learned in greater depth; (2) concepts and material learned in the same depth but in a shorter period of time; and (3) a reduction in the number of students who "simply don't get it". Preliminary results based on student surveys and teacher reactions indicate that more than 95% of the students and 100% of the instructors regard the intelligent classroom facilities as contributing to deeper understanding of the subject matter and to faster coverage of the material. Instructor observations and grades indicate that instruction in the intelligent classroom also achieves a decrease in the number of students who simply cannot grasp the material.

Multi-media, the first increment in capability above the basic classroom, costs on the order of $25,000. Since multi-media classrooms are being installed in universities all across the country, the cost-effectiveness of going that far will be taken as a given. That then brings the question at hand as to whether the extra expenditure beyond that for the intelligent classroom carries enough of a pay-off. In other words, "Can the expenditure of an extra $75,000 for the previously described second, third and fourth increments be justified?"

The cost-effectiveness evaluation literature of potentially significant advances such as the intelligent classroom is not exactly robust. Abdelraheen [1] and Siragusa [5] indicate that, for the most part, it consists of subjective assessment of various factors. The evaluation modes for the intelligent classroom include:

1) Evaluation by students and teachers by means of end-of-term comments or surveys.

Opinions of students and teachers are a good source of data, and suitable surveys are presently being used to gather such information. Results have been extremely favorable.

2) Comparison of learning results in one or more courses done both in a multi-media room and in an intelligent classroom and taught by the same instructor. It is felt that the latter mode can provide the most rigorous and comprehensive assessment of the intelligent classroom. Budget permitting, it is planned to do that during the 04-05 and 05-06 academic years. That will yield four replications of the experimental design, which should provide an adequate data pool from which to draw conclusions. The assessment procedures to be used are described below.

The proposed effectiveness assessment of the intelligent classroom has been conceived in terms of a systems development course to be taught by the same instructor in both a multimedia and an intelligent classroom environment. Using the same instructor will minimize teaching anomalies in the two course sections. In the course, a term project is required of every student. An analysis of the types of errors committed by students in this term project will be used for assessment purposes. If it can be shown that the students in the intelligent classroom committed fewer or less serious errors than their counterparts in a multimedia classroom, then this would be an indicator of added effectiveness. Criteria that will be included in the assessment on the "process-oriented" part of the course include: (1) the number of rote errors that are committed in dealing with violations of the basic rules of data-flow diagrams; (2) how well items are defined, including data elements and processes; (3) how well the CASE software (e.g., Visible Analyst) is utilized to draw the diagrams; (4) the extent to which processes are exploded to the proper level of detail; (5) whether data flows provide consistency between inputs and outputs to process; and (6) the total number of diagrams submitted per project and their appearance. Analogous measures would be included to deal with the object-oriented part of the course.

The evaluation of the above criteria in the final reports or projects submitted by the individual students in both sections of the systems development course will be done by an independent, experienced systems development instructor. The evaluation will be "blind" because the independent party will not know whether a given student was in enrolled in the intelligent classroom section or in the multimedia classroom section of the course. The student work product requirement will be the same for both sections, and all of the students will have access to the same application software. Furthermore, to assure data integrity for statistical analysis, the same textbooks, class materials, and homework assignments will be used in the two sections of the course.

After the evaluation of the work of the individual students has been completed, the results will be assembled into two sets based on the sections in which the students were enrolled. An independent, experienced statistician will then apply the statistical analysis described below to ascertain whether the difference in results for the two groups are statistically significant. As a last step, other factors such as the GPA in information systems courses of the two student sets will be compared. Should there be significant differences here, the statistical analysis will be appropriately adjusted. The use of conventional parametric and non-parametric statistical analyses and data envelopment analysis as explicated by Banker [2] and Charnes [3] is contemplated. In the conventional parametric analysis, the t-scores of each objective metric result will be compared between the intelligent classroom group and the conventional multimedia classroom group. The t-scores will reveal whether, for each objective measure, there is a significant difference between these two groups. Non-parametric tests such as the chi-square test will also be applied to provide an understanding of the significance of other variables such as the GPA. These techniques are well understood by most survey researchers. In addition to analyzing data with these conventional statistical methods, we may apply data envelopment analysis in the event that all individual comparisons do not go in the same direction or that they are not statistically significant. This technique is particularly useful in situations where the presence of multiple inputs and outputs makes comparisons difficult.

Data will also be collected from the instructor or the person monitoring the instruction relating to whether there was time to cover additional topics or if a given set of topics were delved into in greater detail in either course section. Another important aspect of the evaluation will be to ascertain and compare the number of students who did not grasp the material at all in each of the sections of the course. This may be assessed by comparing the number of D's and F's given by the instructor in the two teaching environments and also from the independent "blind" evaluation of the student projects in terms of designating certain projects as manifesting "simply don't get it" characteristics.

PRELIMINARY RESULTS AND CONCLUSION

Preliminary results, based on student surveys conducted in systems development classes up to this time, indicate that close to 100% of students regard the intelligent classroom facilities as contributing deeper understanding of the subject matter and making for faster coverage of the material as compared to a multi-media classroom. Those two aspects were specifically raised in survey questions put to the students. They had all taken the prerequisite analysis course in a multi-media classroom. The surveys were conducted on an anonymous basis, and thus students had nothing to gain from answering positively. There has been a similarity of results during each of the three semesters when the surveys were conducted. Initial evaluation results thus look very promising, but it seems prudent to await the outcomes of the more detailed analysis suggested in the previous Section before drawing final conclusions. Should the full evaluation bear out the preliminary results, then a quantum jump in educational effectiveness will have been demonstrated. This should act as a catalyst for nationwide implementation of intelligent classrooms.

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