AN INTEGRATED TEACHING STUDIO AT THE CITY UNIVERSITY OF HONG KONG

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City University of Hong Kong has initiated a studio approach to teaching, starting with modules in introductory science and engineering. Studio teaching replaces the traditional large-group lecture, small-group tutorial and separate laboratory work with an integrated approach. A typical studio session consists of a mixture of discussions, mini-lectures, demonstrations, computer simulations, problem-solving activities, and computer supported laboratory exercises. It utilises computer based teaching materials that emphasise multimedia and interactive learning. Studio teaching emphasises hands-on activities rather than presentation of materials. It focuses on learning rather than teaching. Experience indicates that studio teaching leads to more effective learning and student satisfaction.

1. INTRODUCTION

Rapid advancement in technology not only revolutionises the way research in science and engineering is conducted but also the way knowledge and information are communicated. In response to this advance, as educators we must rethink the content of the science and engineering curricula and reconsider the environment and the materials with which our students learn. Current teaching methodology in Hong Kong is oriented toward lectures and written examinations, and encourages only passive learning and regurgitation. This approach is ineffective for today's students. In addition to specialised knowledge, the current job market often demands skills (communication, co-operation, leadership, and interpersonal skills) that are taught poorly in a lecture-based format. Cognitive research also indicates that real learning and understanding are better accomplished through co-operative and interactive techniques. Furthermore, being brought up in an era of TV and video games, today's students have limited attention span but they respond well to multimedia stimuli and interactive activities. To counter the trend of declining student interest in science and engineering courses and to keep pace with advances in information technology, pedagogical reform is urgently needed. There are clearly needs for new teaching materials and methodology that encourage different modes of learning. In recent years, as networking, multimedia, mobile technology, and better software converge, educational institutions are discovering new ways to improve learning, increase information access, and save money. Educational innovations and reforms are being implemented at many universities [1], reflecting a rapid change in educational paradigms as summarised in Table 1.

The City University of Hong Kong (CityU) has initiated a studio approach to teaching, starting with modules in science and engineering, especially those at the introductory level with large enrollment. Studio teaching is a teaching methodology that emphasises co-operative and interactive learning, using multimedia

Traditional Model	New Model
* omniscient teacher	* teacher as guide, mentor, and coach
* classroom lectures	* individual/group exploration
* use textbooks, overheads, notes	* use interactive, multimedia courseware
* passive absorption, memorisation	* apprenticeship, hands-on activities
* solve abstract, over-simplified problems	* tackle every-day, real-world problems
* individual work	* teamwork, co-operative learning
* stable content	* fast-changing content; just-in-time learning
* curricula: homogeneous & disciplinary	* curricula: diversified & interdisciplinary

Table 1: Changing Educational Paradigm

courseware. It is designed to accommodate the increasing diversity in student background, expectation, learning style and pace. To adopt the studio approach in teaching science and engineering courses, a learning environment is needed that combines lectures, tutorial discussion, problem-solving activities, and laboratory experiments into an integrated teaching studio (ITS). In particular, a learning environment is needed that fully utilises computer technology, since sophisticated but inexpensive computer hardware is now available, and computer based teaching materials that emphasise multimedia and interactive learning are being developed in the UK and USA. Preliminary results indicate that the studio format is an effective teaching/ learning environment

2. STUDIO TEACHING

Studio teaching is a teaching methodology developed for introductory physics courses at Rensselaer Polytechnic Institute, New York, USA [2][3]. Rensselaer is a research-oriented university with a strong reputation for quality undergraduate education and innovative teaching. Studio teaching typifies changes in approaches to physics teaching that are being widely discussed and adopted in a number of leading institutions. Essentially the methodology replaces the traditional large-group lecture, small-group tutorial and separate laboratory format with an integrated studio approach which is claimed to be both economically competitive and educationally superior. The focus is on student problem-solving rather than presentation of materials. The emphasis is on learning rather than teaching. A typical two-hour session in studio physics might consist of the following activities:

• 30 minutes devoted to discussion of homework problems on assigned reading material

• 20 minutes of mini-lecture by an instructor, summarising the key concepts in the assigned reading, often drawing upon the homework problems for illustrative examples

• 45-60 minutes of group activity which may include (a) mini-labs, in which students analyse data acquired from laboratory apparatus or videos; (b) spreadsheet (numerical) problems, (c) pencil and paper (analytical) problems, (d) exercises involving computer simulation of real-life physical phenomena, and (e) group question and answer sessions. Group activities are a crucial ingredient of the studio class.

• 15 minutes of mini-lecture to preview material on the next reading/homework assignment**.**

At Rensselaer students are taught in groups of about 50. The sessions are led by a team of one faculty member and two to three teaching assistants. The studio workspace has 20-25 worktables. There is a computer workstation on each table which can accommodate 2-3 students. At the front of the studio are the teacher's worktable, workstation and projection

facilities. The students interact co-operatively with each other and the teaching team, and the learning is active. The environment allows alternation between large and small group teaching. Experience at Rensselaer indicates that studio teaching creates a powerful link between the lecture materials and the problem-solving and hands-on laboratories, a link that is tenuous at best in the traditional course.

3. THE INTEGRATED TEACHING STUDIO (ITS)

The philosophy behind the studio teaching format and its ingredients may be summarised as follows. Learning is more effective (a) by doing (mini-labs, exercises), (b) by interactive and co-operative techniques (discussion and group activities), (c) if more of the senses are engaged (interactive multimedia courseware), and (d) by immediate application and follow-up (in-class assignments).

To adopt the studio approach to teaching, the classroom must encourage extensive interaction amongst students and between students, staff and teaching assistants. The ITS is a specially equipped classroom that combines the traditional approaches in lectures, tutorials and laboratories in an integrated environment enhanced with interactive multimedia learning. Laboratory-based material, instrumentation, simulations and demonstrations are integral parts of ITS. The ITS at CityU has the following characteristics. It will house up to 60 students, with 30 worktables. Students sit in pairs at worktables, each of which is equipped with a multimedia workstation, a Universal Laboratory Interface (ULI) which connects the workstation to numerous types of measurement devices, and one or more pieces of laboratory apparatus. To eliminate the obstruction of views by workstation monitors and to maximise flexibility in space utilisation, the workstations are embedded beneath the table tops so that the studio can also be used for traditional lectures if necessary. The student tables are arranged in an open configuration that facilitates student-student interactions and the circulation of instructors about the room. At the front of the studio is a table used for mini-lectures by the instructor and presentations by the students. This central table is equipped with a workstation whose monitor can be viewed on an overhead screen and also with an ordinary overhead projector. The workstations are high-end personal computers linked by a local area network and connected to a server which can also serve as the instructor's workstation. The ITS will also be equipped with video conferencing capabilities for distance learning activities.

4. COURSEWARE FOR STUDIO TEACHING

An important ingredient of studio teaching in science and engineering is the use of courseware. Among the commercially available courseware for multimedia and interactive learning, there are two that are most suitable for studio teaching and have indeed been adopted in many universities in the USA and the UK. These are: the Comprehensive Unified Physics Learning Environment (CUPLE) [4], and the Electronic Design Education Consortium (EDEC) courseware [5].

4.1 Comprehensive Unified Physics Learning Environment (CUPLE)

CUPLE is a powerful, interactive multimedia courseware for teaching and learning physics. CUPLE was developed by a consortium of schools and individuals. It uses the computer as an interactive platform for the study of physics. It unifies teaching ideas and materials from educators around the country and provides immediate access to a robust assortment of learning tools. CUPLE's integrated environment stresses the importance of interaction, which promotes greater subject awareness and understanding. The CUPLE

environment consists of a set of instructional modules on various topics. The modules are linked by buttons to a CUPLE toolbox that can start up a word processor, a spreadsheet, an object-oriented programming environment, run 2- and 3-D graphing tools or symbolic manipulation software (e.g., MAPLE), open hypertext reference books, and perform other tasks. The CUPLE toolbox also comes with software that interfaces the ULI and similar devices to the workstations and their CUPLE graphical analysis tools. These interfaces enable students to analyse real-time data from a variety of measurement devices. This tool allows students to take measurements directly off the screen, enabling them to analyse motion and other time-dependent phenomena and to study systems (e.g., falling bridges) that would be difficult or impossible to bring into the classroom.. CUPLE also has an authoring system for teachers to develop their own programs and lessons. CUPLE can be used anywhere learning or teaching takes place: lectures, laboratories, workshops, recitations, homework, and independent study. The CUPLE courseware is distributed by the *Physics Academic Software,* a non-profit organisation.

4.2 Electronic Design Education Consortium (EDEC) Courseware

EDEC is part of the Teaching and Learning Technology Program, a major initiative of the UK Higher Education Funding Councils. Formed by 8 universities in the UK in 1992, EDEC is dedicated to the production of computer-based teaching and learning material to support the education of electronic engineers and computer scientists. Over 20 academic staff and 16 research assistants are engaged in working on the EDEC project which has a total budget approaching US$1.5M over three years. A total of 160 hours of courseware have been developed, at roughly US$10,000 per hour. Over 100 members, mostly universities, now subscribe to the courseware by paying an annual fee. CityU has been designated the first university outside the UK to be part of EDEC. CityU would work closely with them on the further development of courseware, as well as investigating the possibility of designing bilingual components, and laboratory based modules.

The EDEC courseware is divided into the following four themes: (a) Electronic Circuit Design, (b) Digital Design, (c) System and High-Level Design, and (d) Testing and Design for Test. Each theme is structured from modules with varying degrees of interdependency, allowing an instructor to pick and choose to suit his/her needs. The courseware is delivered on CD ROM disks. It incorporates the necessary run-time versions of the multimedia software and links to tools. The screen is divided into information and interaction areas. The student navigates through the module with a friendly graphic user interface, selecting icons or multiple-choice answers, and performing interactive on-screen real-time laboratory experiments. Text, graphics, animation, and video and sound clips, present information in the manner best matched to the nature of the content. Problem-solving, requiring the use of both of techniques covered in the courseware and those specified as pre-requisites, is built-in, with loop-back to enable the student to retry when a topic is not fully understood. This reinforces the learning process and provides, informally and formally, a measure of progress or a facility for assessment.

5. APPLICABILITY TO CITYU

There is now growing international acceptance of (and action on) the appropriateness of the studio teaching format and recognition that it represents a major, future trend in teaching approach that can be generalised not only across the science and engineering disciplines but to all other disciplines.

There are specific factors which make the approach attractive in the context of CityU. Feedback from CityU students on the quality of small-group, tutorial teaching indicates severe difficulties in certain areas. The studio approach incorporates flexibility in that students can work effectively in large or small groups with the instructors working as a team. This team approach will greatly enhance the training, monitoring and development of tutors. The teaching environment will also prove appropriate for self-directed learning. This would be particularly beneficial to part-time students allowing more flexibility in weekly attendance patterns and the utilisation of "distance learning" type delivery.

In the past year, some ingredients (e.g., group activities, in-class assignments, use of courseware) of studio teaching have been incorporated into some advanced physics modules taught by one of us (CML) at CityU, e.g., "Modelling Techniques in Physics" for 3rd-year physics students and "Survival Skills of Research Scientists" for postgraduates. Feedback from students is positive and encouraging. It indicates that the studio format leads to more effective learning and student satisfaction.

6. IMPLEMENTATION

The implementation of studio teaching using the ITS at CityU is being carried out in two phases, with some overlap between them.

Phase 1: *Classroom renovation and pilot implementation*

In this phase the required space is being converted to create the ITS. It is planned to complete the renovation and furnishing of the ITS in the summer of 1996. A pilot programme will start in Semester A 1996-7 to implement studio teaching in a couple of modules at the introductory level in Physics and Electronic Engineering. These modules are for first-year students and have large student enrolment.

Phase 2: *Assessment and development*

The goals of the second phase are: (a) assess the effectiveness of the studio teaching methodology, (b) customise commercially available courseware and pursue in-house development of multimedia and interactive courseware, (c) extend the studio teaching format to other modules.

During and after the pilot implementation of studio teaching in selected modules, the effectiveness of the studio teaching format will be assessed in terms of: (a) utilisation of teaching resources, e.g., time and effort needed by teaching staff to prepare coursework using the EDEC and CUPLE courseware as a basis for both lecture presentation and tutorial work, (b) student satisfaction and learning efficiency. In parallel with this assessment work, the customisation and modification of the CUPLE and EDEC courseware will be pursued, and in-house development of other teaching materials initiated. Customisation is necessary to accommodate the different course contents and student background at CityU. For example, appropriate Chinese translations may be inserted in the courseware. In addition, structured programs for other Physics modules will be designed that can utilise the studio teaching format, e.g., Electromagnetic and Nuclear Radiation, Physical Measurement & Instrumentation.. In EE a parallel programme will continue to develop an interactive multimedia aid to first year EE laboratory work. One of the 'units' is ready for evaluation in a laboratory session at the beginning of Semester A of 1996-7.

7. CONCLUSIONS

In conclusion, we expect that the creation of ITS, a technologically sophisticated, highly effective teaching/learning environment, and

the adoption of studio teaching philosophy at CityU will:

(a) lead to more effective learning and student satisfaction due to: a truly interactive, participative approach with a focus on problem-solving and active learning; the use of properly integrated (as opposed to overlaid) technology; a team teaching approach that will enhance training and development of tutors; the opportunity for students to repeat and/or extend study activities at their own pace; the encouragement for students to take more responsibility for their own learning and the development of self-learning attitudes.

(b) lead to more effective use of resources due to: utilising a team teaching approach; teaching students in groups of 50-60 due to the flexibility afforded by the studio concept; the availability of teaching resources outside normal teaching hours.

(c) provide opportunities for continuing development and innovation by extending the approach to other modules and disciplines.

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