A NEVER-ENDING JOURNEY: DEVELOPING AN APPROACH TO LIFELONG LEARNING IN COMPUTER SCIENCE

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ABSTRACT

This paper presents an approach to learning across the lifespan, and enhancing effective delivery of computer science courses by bridging the gap between theory and practice. Experiences in applying this approach at different levels of computer science education are described.

INTRODUCTION

The computer is an omnipresent component of the modern era. Both explicitly and implicitly, the computer affects every aspect of life. Some understanding and knowledge of computers and computing is important because almost all occupations now involve some direct contact with information technology. Clearly, the computer is a powerful social artifact within society. In particular, many careers require detailed knowledge of computers and of computer science.

Knowledge of computers and computer science involves the mastery of complex theories and concepts. One approach to such mastery is through formal educational programs, another involves self-education based on practical experience as opposed to formal training. There is a tendency to regard these two approaches as disparate, whereas we believe that they should be regarded as complementary. Each approach, in its own way, can provide understanding and knowledge. However, our concern is with the formal educational process and its failure to equip graduates with effective practical computing skills, and its inability to provide for learning beyond formal university education.

In this paper we demonstrate an innovative model which successfully combines both approaches to develop lifelong learning skills in computer science students. Learning needs to be a lifelong process, as previous divisions of a person's lifetime into an educational phase followed by a work phase are no longer applicable (Gardner, 1991). Professional activities, especially in fast and continually evolving disciplines such as computer science, have become so knowledge intensive that learning has become an integral and mandatory part of work.

AIMS AND APPROACHES TO LIFELONG LEARNING

The concept of lifelong learning is not new. The term was recognised by Dewey in the early nineteen hundreds and was given currency by the OECD in the nineteen sixties. Nineteen ninety six was deemed the *European Year of Lifelong Learning* (Elliott, 1999).

In 1994, the Australian Government commissioned the report *Lifelong Learning – Key Issues* (NBEET, 1996), and a UNESCO conference, *Teaching for Life Skills and Sustainable Development*, was held in Bangkok in 1995 (Clements, 1998). Although the concept is not new, what constitutes lifelong learning continues to be problematic (Smith & Spurling, 1999).

Traditionally, the concept of learning is associated with formal education. Indeed, many of the notions of lifelong learning derive from ideas and practices within the formal education system. One consequence of such an intellectual position is that post-compulsory education comes to be equated with higher education, and thus the skills and practices needed to nurture a learning culture that will sustain concepts of lifelong learning are neglected (Elliott, 1999). This latter point constitutes the major criticism of the 1996 report to the Australian Government – lifelong learning was seen as an extension of the formal educational system rather than as an entity that existed complementary to it.

Of course, the formal educational system must make a significant contribution to the development of the culture of lifelong learning. However, it is one of the contentions of this paper that changes are needed in the nature of formal teaching and learning processes in order to support and effect notions of lifelong learning. The concept of lifelong learning requires a fundamental reconceptualisation if it is to have a significant impact within society. The current mindset about learning, teaching, and education is dominated by a view in which teaching is often fitted "into a mold in which a single, presumably omniscient teacher explicitly tells or shows presumably unknowing learners something they presumably know nothing about" (Fischer, 1999, p 22).

Such a model has little relevance to the modern world in which knowledge that students will require in their working lives cannot be provided during their formal schooling period. In addition, trends such as frequent career change and rapid technological change suggest that a model of learning is needed that will assist people to cope with these challenges.

The model needs to recognise that lifelong learning involves a new learning culture (Smith & Spurling, 1999) or, to phrase it another way, the development of a new 'mindset' in which learning is seen as multi-dimensional, involving self-directed learning, learning on demand, informal learning, and collaborative and organisational learning (Fischer, 1999). For this model to be accepted, there is an additional need for the formal education system to itself undergo transformation. In particular, the development of the concept of lifelong learning will, necessarily, have an effect on curriculum.

A roundtable on *Teaching for Life Skills and Sustainable Development* (Birch, 1996) made the following recommendations for curriculum development.

1) The curricula of schools should be based on real-life needs and future requirements of citizens.
2) Curriculum innovation should focus on life-management skills, divergent thinking, problem solving, and entrepreneurial skills – all underpinned by a commitment to maintaining and enhancing human dignity.
3) Curriculum development for lifelong learning should take advantage of new educational technologies, and new information and communication technologies.
4) Curriculum development for lifelong learners must be learner centred and action-oriented, and based on the needs of the learner and the community from which the learner comes.
5) Experiential learning should be the basis for all curriculum development utilising case studies, project work, practical activities, and other alternative strategies.

Although these recommendations point the way to new approaches to curriculum, it is doubtful that of themselves they will have much impact on the way in which individual curricula develop. One of the major problems is the resistance to be found within the current educational culture. Those who have been successful within the current educational mode have risen to positions of control of the main learning institutions of the country. "Learning practices and institutions tend to be conservative, because each generation tries to bring up the next in ways based on its own experience" (Smith & Spurling, 1999, p 14). Thus, even among universities that subscribe to the rhetoric of innovation and difference, the primary course of study remains the three year degree, and the lecture retains its pre-eminence as the major mode of delivery. Too often, taking "advantage of new technologies" is a formula for doing the same old thing more 'efficiently'.

Lifelong learning is not a passing fashion – a temporary aberration upon the educational scene that will run its course and fade into obscurity in the near future. It is rather a response to the educational needs of the community into the twenty first century. It recognises the changed circumstances of learning, and the necessary interdependence of work and educational cultures in the development and sustenance of individuals and the community. It is not a replacement for the formal educational system, rather it is complementary to it.

If the formal educational system is to play its part properly, it will need to adapt to also support and encourage the development of alternative approaches to education epitomised by the concept of lifelong learning. It is with this latter point in mind that we have developed a number of courses, at differing levels of maturity, to reflect alternative, yet equally effective, ways of helping people to learn the major concepts of computing and computer science. Formal knowledge necessarily rests on a solid theoretical foundation, but the construction of this foundation can be built on the practical and real-life experiences of the learners.

DEVELOPING A LEARNING MODEL

Computer science as an academic discipline invariably includes theory, abstraction, design, and implementation. The general perception is that computer science courses have too strong a theoretical focus, which is also reflected in the way these courses are taught. Concepts are often discussed in theory and are not thoroughly demonstrated, let alone practiced by the students. This makes theory 'unattractive' and even further detached from reality. To make the theory more applicable and 'likeable', and to achieve effective education, theory should be closely integrated with practice. Subject matter should be taught in a manner that engages the student's interest and possibly connects each topic with the student's own life and experiences.

Courses need to place an emphasis on the integration of theory and practice. Only through the integration of learning and working environments is it possible to learn about sophisticated theoretical concepts in the context of real-world problems (Sachs, 1995). The learning model needs to simulate this experience. Concepts need to be introduced and explored in terms of practical experiments that enable the students to master the requirements of the application while at the same time reinforce theoretical comprehension. We engage students in the subject matter by presenting course material interactively and encouraging class participation. Students take part in the actual execution of real software programs. This approach promotes concept demonstration using examples that illustrate practical application of the underlying theory. Students gain increased control over their study and are encouraged to pursue exploratory techniques.

CASE STUDIES

The following case studies illustrate the approach we have adopted in providing students with skills that are needed for lifelong learning. The examples describe an application in a high school environment, an experience with undergraduate students, and an approach that was used in a Masters course.

High School

The Australian Computer Society organises annual Summer Computer Workshops for Year 10 students. These workshops are designed to improve and promote computer science education in high schools. Last year, we designed, coordinated, and presented activities for both students and their teachers for the workshops. Our presentation, called 'Fun With Faces', was an interactive exercise aimed at exploring digital image processing and illustrating its close relationship with simple mathematics. The instructions were interwoven with hands-on participation. Continuous student feedback helped navigate the group through the session.

In preparation for our workshop, we set up a portable 'photo-shop', i.e. a digital camera connected to a laptop computer to capture the face of each participant as a digital image The images were stored on disks and then processed by the participants on their computers. The image processing involved the use of digital masks to achieve sharpening and blurring of images, create prominent contours, superimpose several images and generate poster-like simplifications of original images.

At the beginning of a session, we gave a short rationale for image processing and introduced basic image acquisition and manipulation methods. Participants were then asked to proceed with the first few exercises, described in detail on their exercise sheets. Having succeeded in these early exercises, the participants were encouraged to hypothesise and then experiment. We suggested various 'tracks' to explore, and captured the group's attention with pertinent questions. Later in the session, the students were taught how to use mathematics to 'soften' digital images. They were challenged with exercises that incorporated the initial material presented and their earlier practical work. Students saw the direct link between theory and practice, and could easily relate one to the other. They designed and implemented steps to achieve the desired outcomes, rather than merely observing mysterious results of pushing buttons or making menu choices.

Undergraduates

Methods of instruction for many undergraduate courses in database systems still primarily focus on lectures and a single, all-encompassing project to reinforce database concepts. Thus, many database concepts are discussed in theory and are not adequately demonstrated. Moreover, students only have the opportunity to apply their newly acquired knowledge when working on the project.

Our experience with undergraduate students relates to an intermediate course in database systems that combines the relevant theory on database modeling and transaction specification. Hands-on experience is intrinsic in the delivery of the subject. Students are exposed to the latest technology for transaction implementation, and to current developments in database applications. In order to effectively teach the course, we closely follow industry trends and incorporate, whenever possible, current methodologies and latest software. This enables students to keep abreast of the most recent industry developments and adds 'real-life' relevance to the course. To convey the dynamic nature of many fundamental concepts, such as database transactions, we use a presentation PC to give live demonstrations of database transaction processing. The power of rapid application development tools, such as Oracle Developer/2000, is also best illustrated via a presentation PC. Students can then witness an almost immediate development of a working application prototype.

Chickering & Gamson (1987) presented a list of principles for undergraduate education. Two of these principles are the encouragement of active learning, and cooperation amongst students. To promote cooperative learning, and help students develop the ability to work productively in a team environment, a database assignment is conducted in groups. This assignment encourages active learning by providing a concrete task for students to solve. This type of team learning also helps build collaborative skills and promotes a sense of joint responsibility.

In teaching database application development, we aim at integrating the relevance of theoretical considerations with software development practices. To this end, we emphasise that the creation of a working code plays a relatively small part in the total development process – particularly in the construction of non-trivial systems. More important is the thinking process involved in analysis and design. This approach to database application development is reflected in practice in the database assignment, which includes analysis, specification, and subsequent implementation of database transactions. Students are presented with a set of basic requirements which allow a certain amount of latitude. They are instructed to formulate their own assumptions and to then produce a consistent design. Students are expected to follow the design concept from its inception through delivery. They are also required to fully document their work. Finally, the students give a short presentation of their 'product', putting forth arguments to support its strengths and defend its weaknesses.

Developing student interest and confidence is important to the effective delivery of any undergraduate course. While following the syllabus and the prepared material, we frequently answer queries and discuss related problems and additional examples. These interactive exchanges not only illustrate the potential diversity and complexity of database design and application design problems, but also stimulate student interest and encourage students to be actively involved in both the formulation of problems and of their solutions.

Postgraduates

Masters students comprise a heterogeneous group, with considerable differences in computing background and vastly varied work experience. Unlike undergraduate students, they already know the fundamentals of computer science. They are often practicing computer professionals who seek to upgrade their qualifications. In general, the Masters students anticipate exposure to cutting-edge technologies, and extension of their computer science skills.

Our experience relates to a Masters course in Database Design, Management and Administration. This course presents the issues involved in modern database technology and in the development of new database systems with emphasis on administration of relational databases. Appreciating the computing industry need for database professionals with experience in database administration, we included a substantial practical component in the subject. We created twelve individual full-scale database systems, so that students could act as independent database administrators. Since there are always more students enrolled in the course than there are database systems, the students naturally form groups of two or three to a database system. Despite the restrictions on the individual's control over a single database system, this arrangement has an overall positive effect as it supports teamwork and collaborative learning.

To provide students with reasonable hands-on experience in database administration, we include a core set of database administration topics that must be covered in a single semester. These topics cannot be presented in a random order as they must be practiced in a predetermined sequence. They comprise a series of carefully composed steps from the initial system installation through backup and recovery where the subsequent work depends heavily on previous exercises. Real research questions are also integrated with the studies and selected research papers are used to supplement standard presentations. Extensive simulations of real life scenarios are undertaken. They include the simulation of complete system failures and their subsequent restoration and recovery. The content of the lectures is driven to a large degree by the requirements of the laboratory classes. However, the course syllabus is never compromised as lectures follow two parallel streams: one covering database design and management, the other practical database administration.

Students enter this course usually with extensive practical experience. By utilising this experience we are able to make them realise that the solution of real world problems requires not only the application of practical skills but also a sound understanding of theoretical concepts.

DISCUSSION

The high school students participated in a workshop that utilised a software package which offered a discovery-rich environment and allowed the use of exploratory techniques. The combination of hands-on practice and immediate feedback elicited a favourable qualitative response from students and teachers alike.

The undergraduate database course was designed to promote immediate concept reinforcement through tight integration of theoretical concepts with practical application. A preliminary survey, administered by the authors, confirmed the effectiveness of this approach. All of the students rated the course above average, with 58% giving it the highest score. In addition, qualitative feedback was very positive, with students describing the course as "challenging", and the laboratory exercises as "highly stimulating." A pleasing byproduct was the students' enthusiasm for working in teams.

The Masters course in Database Design, Management and Administration was designed around extensive, realistic, and meaningful involvement with real life computer applications. Conceptual development flowed from the engagement with the problems and challenges posed by the day-to-day operation of full scale commercial computer systems. Independent, voluntary, and anonymous evaluation of this course was conducted by the Centre for Educational Development and Support (1999). The questionnaires used five point Likert scales which ranged from 'strongly agree' to 'strongly disagree.' The categories evaluated were: content, mode of study and assessment.

Eighty-seven percent of respondents ranked both the mode of study and the content of the course as above average, with 40% giving it the highest possible ranking. A majority of students indicated that "aims and objectives of the subject were clear", "subject content was structured and delivered in ways which assisted learning", "subject content was organised and presented in a logical and coherent way", and "a great deal was learned in this subject". Eighty-one percent of students endorsed items such as "making students active learners", "contributing to a positive learning environment", "encouraging productive team membership", and "compares well with the organisation of other subjects". Similarly, some 82% of respondents found the assessment methods as "compatible with subject objectives" and "useful learning experiences".

CONCLUSION

The case studies illustrate that practical activities and project work can enhance the formal educational process in a way that increases both student practical skills and their understanding of theoretical concepts. The introduction of 'work-related' activities into our courses highlights the interdependence of the work and educational processes, and reinforces the notion that education is part of lifelong learning. That the courses were so successful demonstrates that the traditional goals of education are not compromised by this change.

Unless students are taught to view the work-education dichotomy as a cooperative process rather than as different realities, it is unlikely that they will readily respond to lifelong learning.

We have addressed changes we consider necessary to the formal educational process in order to open the possibility for lifelong learning. It is then the responsibility of employees and employers to ensure the extension of this process in the industrial and business environment.

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