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ABSTRACT

Since the mid to late 1990s, the World Wide Web has been used as a distributed learning mechanism, enhancing the digital learning environment to support distance and on-campus students. Web technology has been adopted to assist learners with real-time studying at a distance. Consequently, Web delivery has grown rapidly and has been used as a vehicle for learning. Many universities have developed wholly online distance education programs. These changes in distance education have been developed in an attempt to provide easier access to educational opportunities for students who are located remotely from the university, who are working or who have other constraints/commitments such as family commitments. However, online distance learning in Computer Science courses remains challenging for both instructors and students. Research has shown that there is a significant risk factor for online courses in Computer Science. Course developers and instructors need to be aware of the particular needs of Computer Science students when establishing online courses, if they wish to graduate successful and satisfied students. This is particularly true in technical subjects where teaching and learning in an online environment is even more challenging. This paper aims to identify the technological and social enablers and barriers to effective teaching of Computer Science topics in a wholly online environment from the perspective of instructors and learners by using the School of Computer Information Science (SCIS) as a case study. The paper reports the preliminary findings of historical enrolment data from SCIS, to determine if the online environment is a major factor in retention rates for online students.

INTRODUCTION

In an attempt to provide a range of equitable educational opportunities for students who are working or who have other constraints on their time, many universities have developed wholly online distance education programs (Hentea, Shea, & Pennington, 2003). Initiatives to connect to the 'power of the Web' as a mode of delivery and to enhance quality and improve accessibility for education and training, is evident around the world (Pye, 2003; Tabatabaei, Schrottner &Reichgelt, 2006), as educational institutions and business recognize the potential educational benefits and the flexibility of online learning (Salimi, 2007; Shelley et al., 2007). Thus, information communications technologies (ICTs) are being used to attract distance education students with the promise of access to a range of up-to-date, learning materials available in a more flexible learning environment (Tanaka, 2005). Research by Allen and Seaman (2005) found that in the United States current traditional enrolments

are occurring at a rate of four percent compared, whereas elearning or online learning increased at a rate of more than eighteen percent in 2005. A similar finding in American Society for Training and Development (ASTD) (Rossett, 2002) estimates that up to forty percent of education is currently being offered online in Australia (Wagner, 2006).

Several factors are driving this dramatic growth in elearning including rapid advances in ICTs and web-based technologies which allow easier access to a range of different learning materials; lower costs for hardware, software and Internet connection; greater access for prospective students irrespective of physical location; and the provision of just in time, flexible and independent learning programs (Gulatee & Combes, 2007). However, previous findings indicate that many of these initiatives have had mixed success (Zemsky & Massey, 2004). Emerging research also indicates that studying subjects online may be problematic because online programs are often designed without attention to human-computer interaction. HCI is a branch of science concerned with studying the interaction that occurs between human users and computers. However, HCI is much more – it is also about the interaction that occurs between human users and the system, the network and the virtual spaces/environment delivered via the computer screen (DePaula, 2003). When studying online, the virtual environment and how students interact in and with this environment, presents barriers to student engagement. This is particularly true in technical subjects such as programming languages, where teaching and learning in an online environment has proved to be very challenging (Gulatee & Combes, 2006). Many Computer Science subjects are highly technical in nature, which may be more difficult for students to learn independently when working wholly online. This paper presents the preliminary findings of a larger research project which examines the social and technical barriers to the effective teaching of Computer Science topics particularly technical subjects, in an online environment.

BACKGROUND

In the wholly online environment the student is physically isolated. None of the body language and ready/immediate access to the instructor's knowledge at the point of need is available. A major problem with teaching Computer Science topics on the Web is the lack of direct interaction in teaching and learning activities and immediate access to the instructor and peers. Matzen and Alrifai (2006) found that forty-five percent of the students in their research agree that it is more difficult to teach Computer Science on the Web than most other disciplines, especially introductory programming. Students working online in isolation suffer from feelings of anxiety, lack of confidence and frustration (Combes & Anderson, 2006). The nature of the online environment means that students requiring immediate assistance to correct a misunderstanding may not receive it, especially where asynchronous communication is being used as the primary method for feedback. Since asynchronous communication methods are a major component of the flexibility valued by online students, this lack of opportunity for immediate feedback is a major issue, especially in technical subjects (Gulatee & Combes, 2007). Other research by McSporran and King (2005) also supports the idea that cognitive development does not occur in isolation. Therefore, the online environment itself presents barriers to learning highly technical subjects such as computer programming. As a result, programming students are at significant risk of failure or leaving the course when attempting to study wholly online (Hentea, Shea, & Pennington, 2003).

Research by Jehng and Chan (1998) indicates that teaching and learning computer programming in traditional, face-to-face classrooms is also problematic. Computer programming is an area that contains complex knowledge and abstract concepts which challenge an individual and require more mental effort to learn and understand. Computer Science programming subjects require students to become proficient in several cognitive abilities including syntactic knowledge, conceptual knowledge and strategic knowledge (Bayman & Mayer, 1998). Deek and Espinosa's (2005) research in how students learn in programming courses, found that studying subjects such as programming languages is often more difficult, because the courses have been designed without attention to human-computer interaction. Many Computer Science subjects are highly technical in nature, which may make it harder

for students to learn independently in an online environment. In most Computer Science topics such as programming, the syntax of the language has complex rules that are difficult to learn and understand (Lischner, 2002). Novice programmers often find introductory programming courses frustrating and difficult (Deek & Espinosa, 2005). Consequently, Flowers (2001, p.10) noted that "typical students who take their first online course are often unaccustomed to the instructional techniques and mistakenly assume a passive role". As a result, in online programming classes, students find it more difficult to apply the theory of programming problems than in the traditional face-to-face classroom (Hagan & Lowder, 1996). Students studying wholly online need to develop learning strategies, understand language syntax and utilize their problem-solving skills to solve programming problems creatively or to construct new programs, as well as be able to troubleshoot when the program does not work as expected. Highly technical subjects such as programming languages which are already difficult to teach in traditional learning environments, present additional problems for instructors and learners when provided wholly online, where the added factors of isolation, anxiety and lack of feedback are part of the online learning environment.

TEACHING APPROACHES, COMPUTER SCIENCE AND ELEARNING

Traditional classroom or face-to-face teaching provides students with opportunities to work with experts in their field of study. In a traditional classroom setting concepts become immediate and personal through students' interactions with both their instructors and other students. These traditional interactions contribute a social and emotional focus that gives students a chance to compare themselves in terms of performance, problems and priorities. Traditional classes also give students a chance to benefit from other students' questions, mistakes and insights. In the wholly online environment the student is physically isolated. None of the body language and ready/immediate access to the instructor's knowledge at the point of need is available. A major problem with teaching Computer Science topics on the Web is the lack of direct interaction in teaching and learning activities and immediate access to the instructor. These are issues that need to be considered when teaching programming languages, because these approaches are not often compatible with elearning. Due to the nature of elearning, where students and the instructor are located in different places geographically, it is impossible for the instructor to teach the students on a one-to-one basis as often happens in the programming classroom. The hands-on approach often used by instructors when teaching programming languages is very difficult to simulate in the online environment. When working on programming students need to have instant feedback, opportunities to share information and problem-solving strategies. Programming courses require students to set up software to execute their programs using the available platform provided by the university. If each online student is using a different platform such as UNIX, Windows or Linux, this fact may cause unknown problems or difficulties, even though the students are using the same software. When problems occur while coding the program, the instructor and student may be discussing the same problem, but from a different programming environment, thus creating difficulties in understanding and communication. Thus, teaching units in computer programming tend to use more traditional instructional methods that rely on face-to-face, one-to-one, hands-on learning to cope with the complexity of the subject material. These traditional classroom methods are difficult to simulate online.

THE RESEARCH

Since elearning actually represents a new teaching and learning paradigm, it is essential that educators build on previous understandings to help them appreciate the barriers inherent in the online environment before they can design suitable programs, especially for technical subjects. This research utilized both quantitative and qualitative methods to provide a comprehensive picture of how students approach online learning and how instructors design and teach online subjects. In this research the School of Computer and Information Science (SCIS) at Edith Cowan University provided the test bed for an in-depth case study. SCIS provides online alternatives for nearly all of its courses, with a significant number being offered in mixed mode and wholly online (Anderson et al, 2005).

According to the literature a number of strategies have been suggested to overcome the difficulties of using online as a teaching mode for technical computer subjects such as programming. These strategies include the provision of opportunities for collaboration between academic, technical staff, instructional designers and students to develop learning materials; and courses that meet students' social and academic needs when studying subjects wholly online. Online delivery models should include a range of student resources, facilitator resources and facilitator support. Some researchers also maintain that student resources should include online course material, discussion groups, real time lectures, learning guidelines, textbooks and facilitator notes (Howell et al, 2003). If the technology allows, we could also include low bandwidth images, animated graphics and simulations (simple learning objects), audio, web-based simulations, groupware and multimedia presentations. SCIS has used many of these strategies as a set of criteria when placing Computer Science units online, as well as providing opportunities for staff and students to discuss social and equity issues as part of the development an online learning community. SCIS has also developed a learning culture by the extensive use of discussion forums and chat (Anderson, et. al, 2005). Not only is SCIS an interesting case that demands further investigation because of the above, but as an early and total adopter of elearning, SCIS offers a useful domain for research into the issues associated with the delivery of technical content in both on-campus and online modes.

METHOD

In this research case study method provides an overarching framework for more in-depth research using a range of different data collection techniques to develop a rich description of what has and is happening in SCIS.
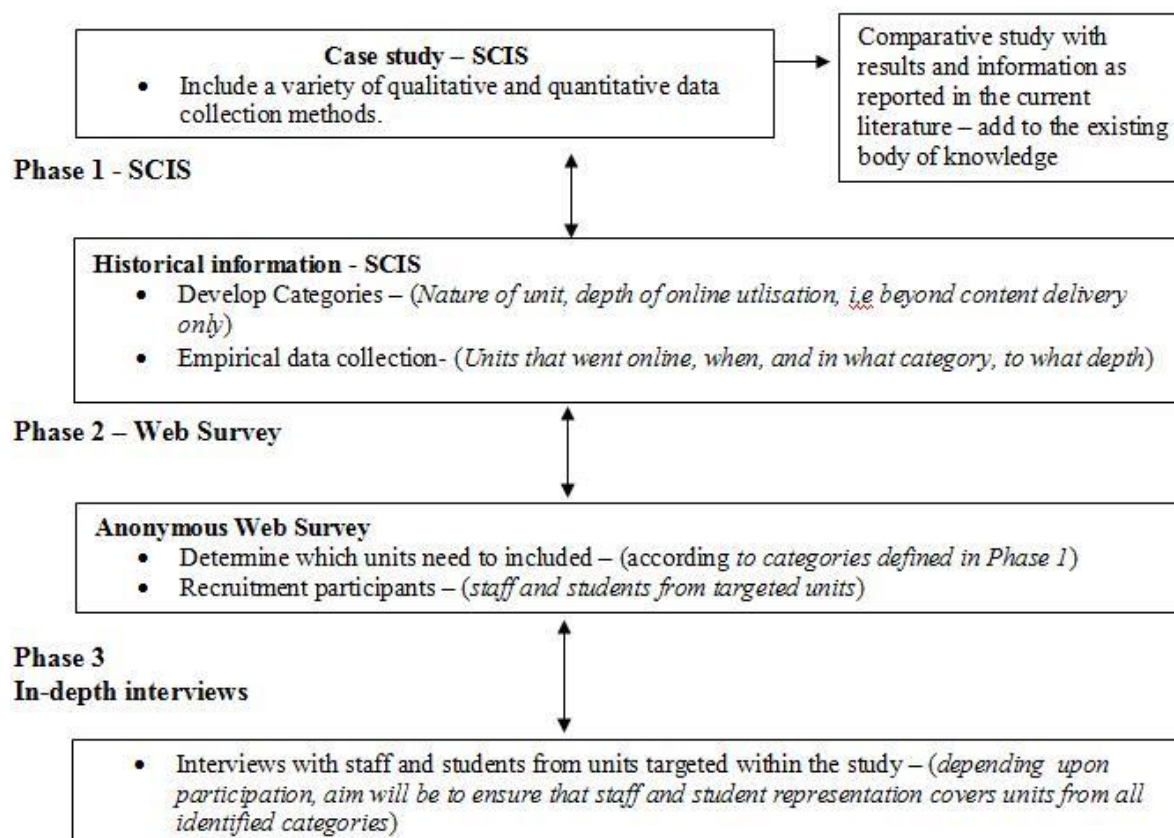

Figure 1: Research Phases

The case study examines whether the technical teaching environment impacts on the Web-based delivery of Computer Science topics and combines empirical research approaches to gather data about those Computer Science units in SCIS that went online first. Categories to define the nature of unit

(unit type) were created and used to establish whether a relationship exists between the delivery mode (going online) and the nature of the subject materials. For example, were the least technical units the first to make the transition to online delivery. Based on best practice for the design of online programs as established in the research literature, another set of criteria were created to describe the content of the online materials created for the SCIS courses. These criteria were then used to analyse the content and establish whether a relationship exists between unit type and the type of content in the units. This data was then used to establish whether technical subjects present more difficulties for staff when creating unit content that represents best practice as defined in the literature. The analysis of this historical empirical data set from SCIS courses relating to the school's adoption of online learning was then used develop two anonymous Web questionnaires, for staff and students. Results from the Web survey were then used to develop in-depth, structured interviews with staff and students who were teaching and studying across a range of unit types in the school. This paper will present and discuss the preliminary findings of the first stage of this research project, the historical dataset relating to the online delivery of programs in SCIS.

Unit Type Categories

To differentiate unit type, a series of categories were designed to describe the nature of units taught in SCIS. These are described in Table 1. The historical data will provide the research with some primary data about the teaching of technical and non-technical subjects in an online environment and may indicate differences between these unit types. This will allow a comparison between unit types using the retention rates and completion rates to determine if unit type is a significant factor. The placing of units within categories was also designed to ensure a level of anonymity for teaching staff, thus removing any concerns that staff were being criticized for their online materials. These categories also enabled the researcher to define the nature of the content in the units and compare the data in each category.

Table 1: Criteria for categorizing units in SCIS

| Categories	Criteria
Technical (T)	This category consists of the technical units in which students have to develop a range of technical and practical skills and conceptual understandings, in order to be able to apply this knowledge to different applications and workplace challenges such as programming, database development and artificial intelligence (AI).
Technical theory (TT)	This category consists of the technical theory units, in which students have to learn theory and conceptual understandings in technical skill but not practical skills, for example, systems analysis.
Non-technical (NT)	This category consists of the non-technical application units, in which students have to know how to use the applications but do not have to create the application software by themselves such as Library systems.
Non-technical theory (NTT)	This category consists of non-technical theory units, in which students examine, discuss and apply conceptual theory, for example, Information Society and Information Services management.
Other (O)	This category consists of generic conceptual theory units, for example Research Methods and Research Proposal and applicable Project units.

Using the unit categories as a starting point, a separate metric was then designed to classify the degree at which a unit had been developed specifically for the online environment. For example, a unit that merely places content online as text would be considered at the low end of the scale, whereas one that includes assessments aimed at online students, communications, multimedia and groupware tools would be at the high end of such a scale. The overarching premise here is that an online unit which

provides a variety of learning materials and formats, and opportunities to interact with the lecturer and peers (ie. a rich learning environment) will be better than one that is sparsely populated and where materials are merely text on screen (Howell et al., 2003). According to the literature, richly populated online units that use different formats and delivery modes, cater for different learning styles and provide opportunities for students to develop further their understandings and skills through guided activities, problem-solving and review exercises. The findings in this paper will only consider the historical enrolment data from SCIS using the above categories, to determine if the online environment is a factor in attrition and completion rates.

FINDINGS

SCIS began offering units online in 2002. An analysis of the historical data found that most of the units offered online between 2002-2005 were classified as non-technical (NT), non-technical theory (NTT) and Other (O) units. Most of the units classified as technical (T) and technical theory (TT) were offered online at a much later date, after 2006. See Figure 2 below.

Figure 2: Units offered online 2002-2008 (blue= not offered, green=offered)

Bar Chart — Offered online in 2006

Bar Chart — Offered online in 2007

Bar Chart — Offered online in 2008
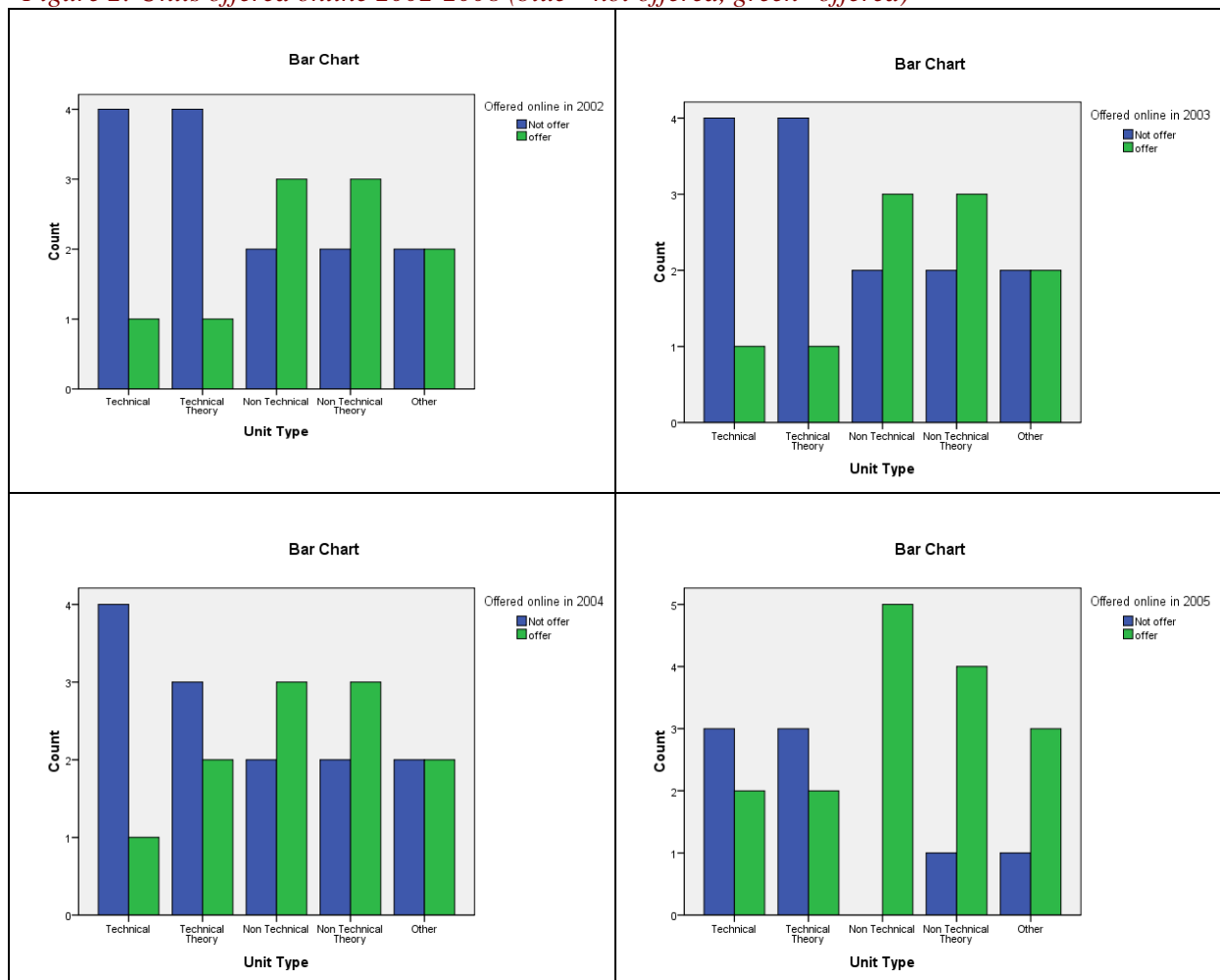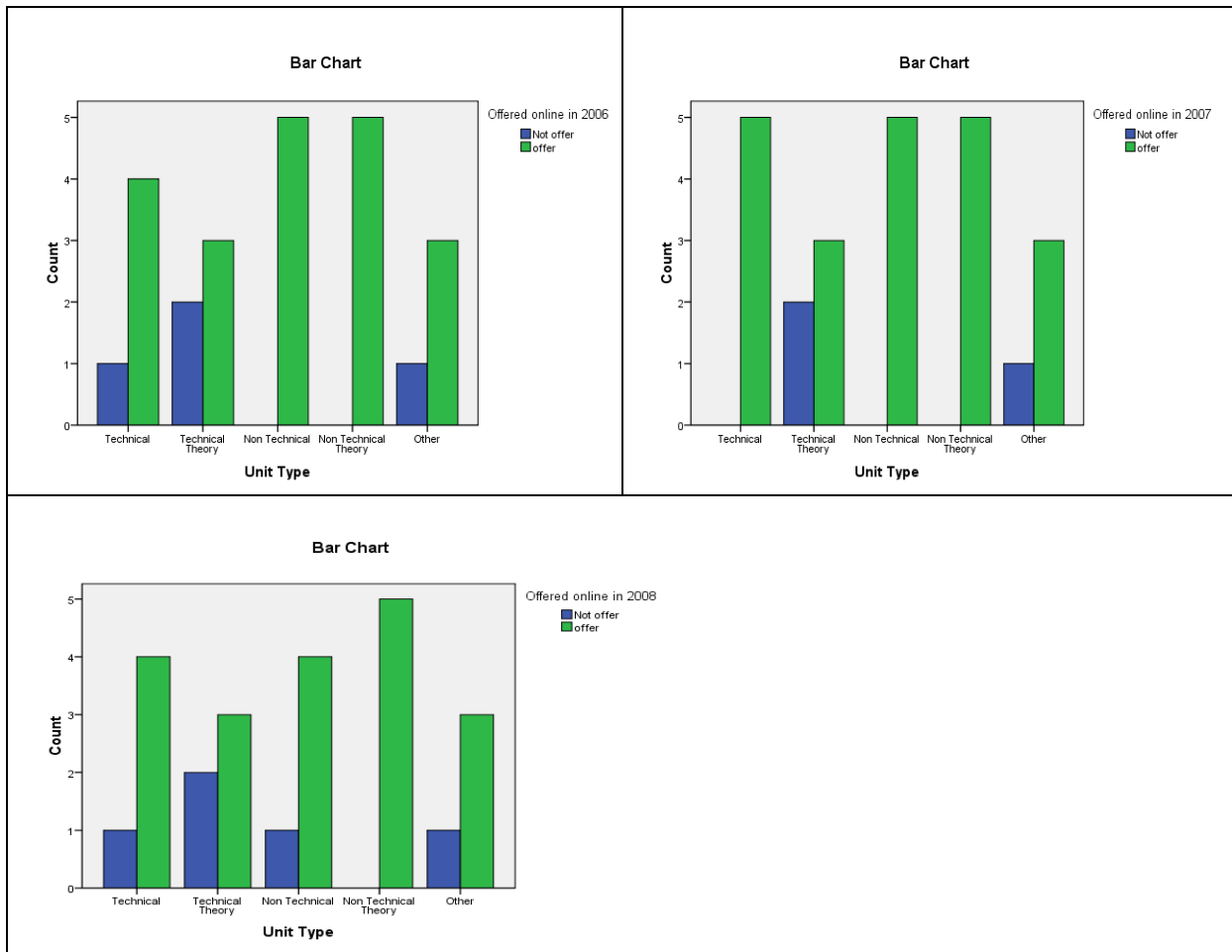
Five units from the categories Technical (T), Technical Theory (TT), non-technical (NT) and Non-technical Theory (NTT) and four from the Other category (O) were then studied in depth to determine enrolment patterns, and rates of student completion and student attrition. Figure 3 indicates total enrolments for the period 2002-2008.

Figure 3: Total enrolments 2002-2008
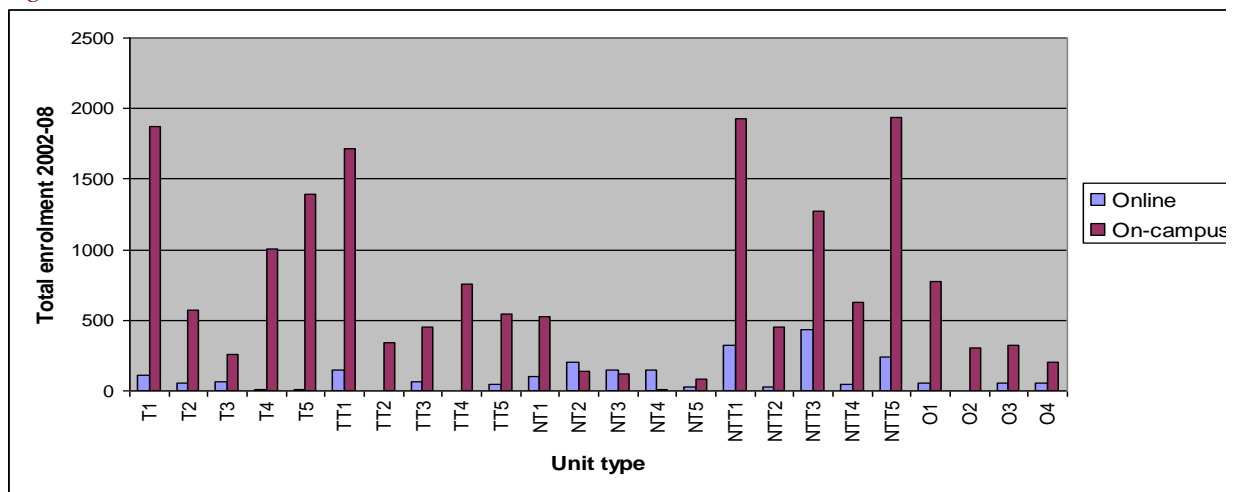
Clearly, students in SCIS prefer to study on-campus for technical and technical theory units, even though most SCIS units also provided materials online by 2006. Non-technical and non-technical theory units attract the most online students. In some cases the non-technical units have higher

numbers of students enrolled online than on-campus. Students' preference for on-campus instruction has been consistently reported in the literature, especially in technical subjects such as computer programming (Peltier, at al., 2007).

Completion and attrition rates for online students for each unit set were also examined. Figure 4 below indicates the total percentage of students who completed and discontinued in Technical Subjects (online and on-campus) between 2002 and 2008. This data clearly shows that the attrition rate for all students completing technical units is high, even when they are studying on campus, and data supports other research findings that technical subjects in Computer Science are difficult for students (Gulatee & Combes, 2006). However, the attrition rate for online students is high across all units except T5, with T4 having an attrition rate that is higher than the online completion rate. It should be remembered however, that online enrolments in T5 were very small.

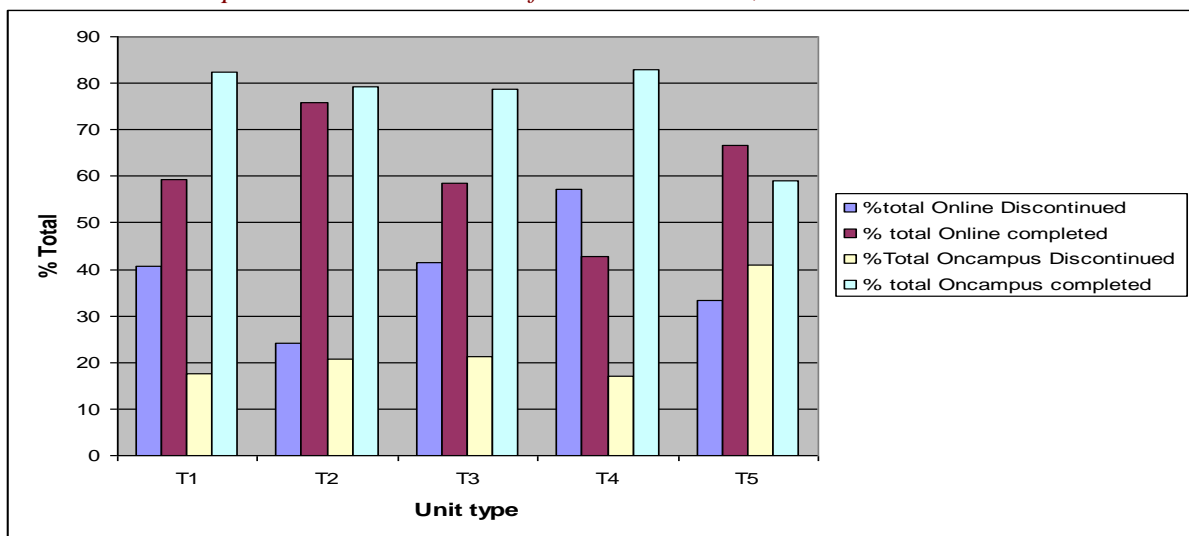*Table 4: Total completions and discontinued for Technical units, 2002-2008*

Table 5 for units classified as Technical/Theory also shows a higher discontinued rate for online students. Interestingly, TT2 and TT4 are two examples of units that do not have an online presence at SCIS. Tables 6-8 show the completion and attrition rates for units classified as Non-Technical, Non-Technical/Theory and Other for 2002-2008. Again, the attrition rate for online students is generally higher than for students studying on-campus. Although other factors are undoubtedly involved here (age of students studying online, access to technology and work/family commitments) which may influence attrition rates, all of these datasets may also indicate that it is the online environment that is a predictive factor that determines the successful completion of a unit. In table 6, NT4 is only offered online and is a core unit, so students must compete it, hence the high completion rate. In table 7, NTT4 has only been offered online since 2006 and has had very low numbers of online students. It is also a core unit for some of the undergraduate degree courses in SCIS.

Table 5: Total completions and discontinued for Technical/Theory units, 2002-2008
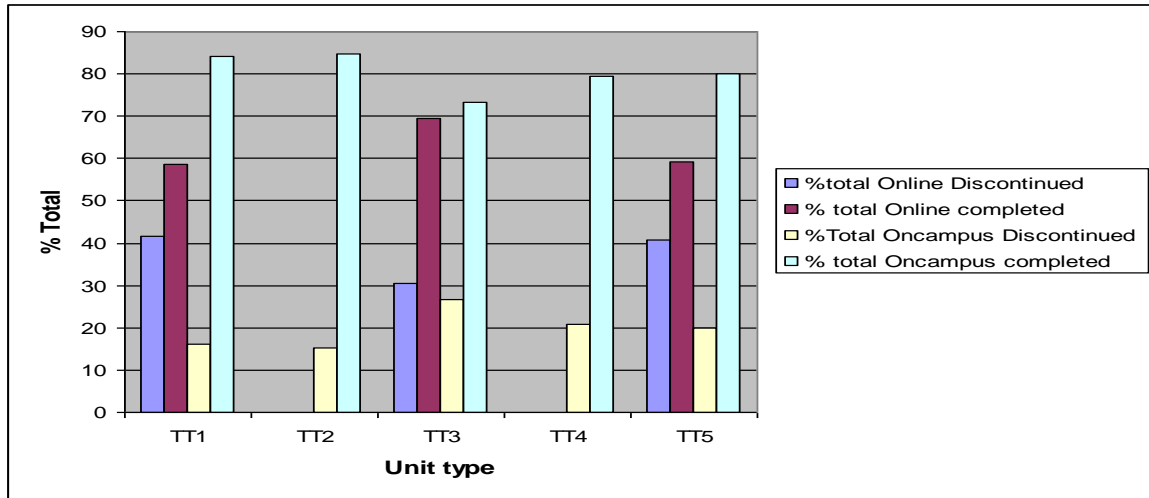

Table 6: Total completions and discontinued for Non-Technical units, 2002-2008
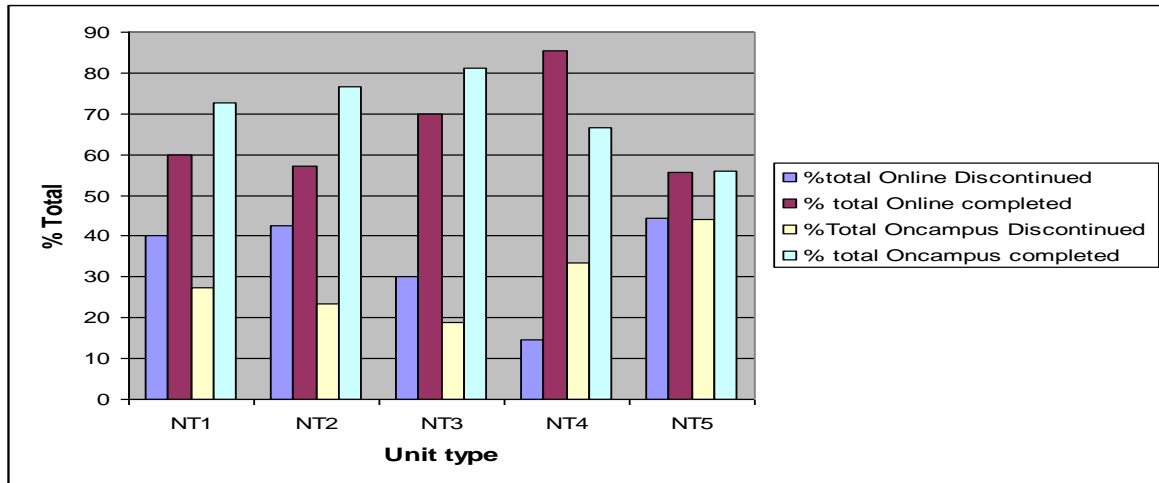

Table 7: Total completions and discontinued for Non-Technical/Theory units, 2002-2008
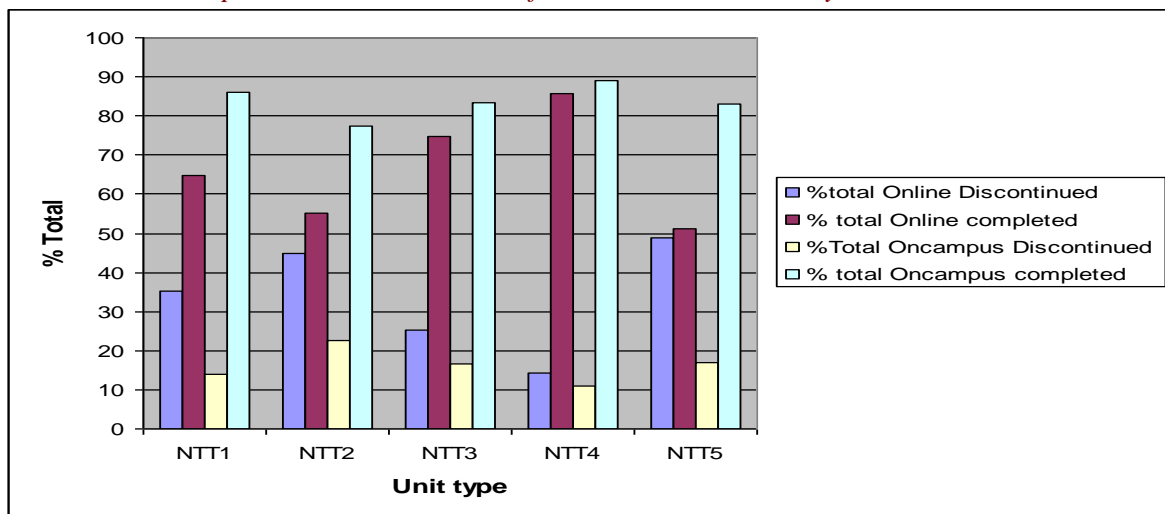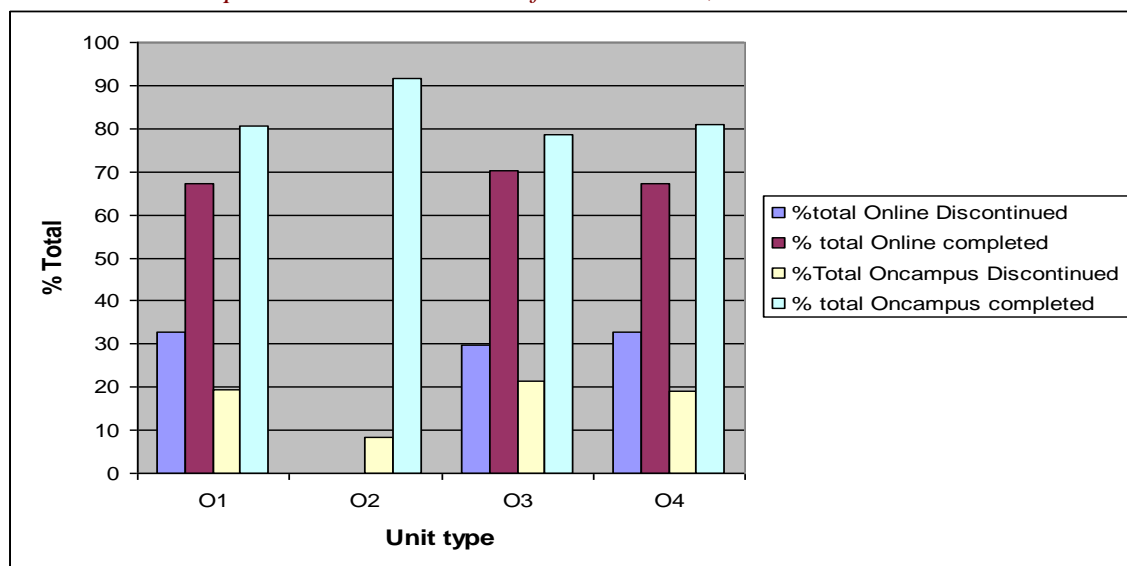
Table 8: Total completions and discontinued for Other units, 2002-2008

CONCLUSIONS

Online education has become a popular alternative to more traditional delivery modes in tertiary education, as it offers part time and working students much more flexibility. To design effective elearning programs that cater for all students, educators must find new ways of improving online education and virtual leaning. To accomplish this objective, instructors need to include a variety of formats that cater for the full range of learning styles, and which allow students to engage with the learning from a number of different perspectives and via different media. Online programs should provide opportunities for consolidation and review and the development of deep conceptual understandings, prompt feedback from the lecturer, assessments that cater for the online student and the inclusion of development environments, especially in technical subjects such as Computer Programming.

While SCIS is an ideal subject for a case study, due to the school's early initiatives in online course development, the findings in the first phase of this research project suggest that establishing an effective online learning culture is not an easy task. Even though SCIS can be considered to be an early adopter of online teaching and learning (2002), the results of this research show that most of technical and technical theory units have only been available online since 2005 and the attrition rates for online students is still high when compared to on campus students. Placing existing materials online will not necessarily meet the teaching-learning needs of students, particularly those studying wholly online. The issues of time constraints and staff professional development, attitude to change and a willingness to participate in online development and learning; may be major barriers to effective elearning program development. This certainly appears to be the case in technical subject areas such as computer programming, which are difficult to teach in the traditional classroom. Developing course materials that will overcome the barriers of virtual communication, isolation, anxiety and lack of motivation so the online student has satisfying learning experience is difficult.

This research indicates online students experience greater levels of difficulty and this is reflected in the higher discontinued rates for online versus on-campus students. Even the number of enrolments for online is much smaller in technical units, indicating that students also feel the need to participate in face-to-face learning. Even though SCIS has been developing online programs for some time, the number of the students who discontinue their course while studying technical units is still very high (more than 50 %). The research literature indicates that teaching Computer Science subjects such as

programming languages is especially challenging and it would appear that teaching in these areas in an online environment has limitations.

Creating successful learning environments at tertiary level include a complex mix of social and academic factors. Students working independently not only need to feel they belong to a wider learning community, but they also need and prefer to have the closeness and social interactivity provided in a face-to-face learning environment. This research indicates that there are other issues that need to be resolved, such as staff participation and a re-assessment of the difficulties involved in teaching and learning in the online environment.

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