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Survival Mode: The Stresses and Strains of Computing Curricula Review

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Executive Summary

In an ideal world, review and changes to computing curricula should be driven solely by academic concerns for the needs of students. The process should be informed by industry accreditation processes and international best practice (Hurst et al., 2001). However, Australian computing curricular review is often driven by the need for financial viability of programs with declining student numbers as much as concerns for academic merit.

Worldwide there remains a strong job market and high demand for computing professionals (Liu, 2007; Melymuka, 2006), which predicates an impending IT workforce shortage. However, computing programs currently do not attract students due to perceived problems of the inadequacy of courses to prepare students sufficiently to cope with the practical challenges in current technologies adoption, to acquire strong communication skills and business aptitude (Taft, 2007), to foster problem solving skills, and to find the relevance of program contents to specific occupations. Therefore, computing curricula wishing to attract students need to have specialized studies that are of industrial strength that are updated regularly to reflect the progress in the discipline (Finkelstein & Hafner, 2002; Lui, 2007). Yet the challenge for universities is to weigh this need against preparing students to be universal and lifelong learners.

Given the impetus to be financially independent, the greatest challenge since 2004 for the School of Computer Science and Mathematics at Victoria University, Melbourne, has been the steady decline in both local and international student numbers. In response, between 2004 and 2006 the School underwent various restructurings, reviews, and assessments to meet government legislative requirements, professional accreditation needs and to capture new market share. In 2007, continued poor enrolment numbers threatened the School's long term sustainability necessitating urgent strategic analysis and decision making surrounding the future of computing programs. It was decided that a new and innovative program embracing emerging computing paradigms was needed to attract potential students. The proposed program structure would be based upon input from industry representatives, senior academics, and government reports whilst operating within existing budget constraints. Essentially, existing programs were to be condensed into a core offering with six specializations in a) Interactive Digital Media and Game Development, b) Web Technologies and Mobile Computing, c) IT Security, d) Computational Finance, e) Business Intelligence and Service Computing, and f) Aviation Technology. The choice of specializations was made to firstly incorporate the major characteristics and paradigm shifts in the ICT industry, secondly to cater for the broad diversity of student

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interests, and thirdly to capitalize on historical strengths. Through these specializations, the program offers prospective students the necessary skills needed for future predicted employment shortages. With adequate marketing, it is hoped that the proposed new structure will allow for quick responses to external positive changes in demand and thus attract student interest.

Keywords: computing education, IT education, academic review, curriculum development.

Introduction

In an ideal world, review and changes to computing curricula should be driven solely by academic concerns for the needs of students. The process should be informed by industry accreditation processes and international best practice (Hurst et al., 2001). The reality in Australia is quite different. In their telling report, *What Drives Curriculum Change?* Gruba, Moffat, Sondergaard and Zobel (2004) conclude that "changes are driven by individuals, politics, and fashion more than they are driven by academic merit and external curricula." Optimistically, they comment that, despite widespread difficulties encountered in Australian higher education institutions, overall computing academics remain confident that the right changes are being made regarding curricula development.

Over the past twenty years there have been "seemingly never ending waves of amalgamation, restructuring and re-organisation of Australian universities" (Saunders, 2006). The amalgamations of technical and higher education institutions began in early 1990s, accompanied by governmental changes to funding models for both sectors, which have impacted greatly on the curricula design and how courses can be conducted (Skilbeck & Connell, 1999). Today, the bottom line is that education institutes are expected to be financially independent. Within each institute, individual operating units need to attract enough students, both local and full-fee paying international students, to justify their existence. Otherwise, they will face either merger or dissolution. A consequence of the need for fiscal sustainability of programs has seen many institutes begin franchise arrangements with offshore partners for the delivery of Australian computing courses.

Against the backdrop of the Y2K scare and dot.com bust, computer science student enrolments have been undergoing a dramatic decline worldwide. For instance, between 2001 and 2005 the number of freshmen who expressed an interest in majoring in computer science has plummeted by 59 percent at one Californian university (Foster, 2005). In Australia, since 2002 the numbers of ICT students has dropped 19% nationally (Multimedia Victoria [MMV], 2007). This alarming trend triggered the State Government of Victoria to commission a survey of the 217 students who planned to go onto university studies, to state their study preferences. Worryingly, the survey found that only 13% of males said they would study IT, whereas no female said that she planned to study IT at university (MMV, 2004).

This trend of diminishing student enrolments, together with the need for financial independence, is having an adverse effect on many Australian computing faculties, undermining their continuing survival. Accordingly, this paper looks in detail at the current challenges faced by IT faculties, and then describes the local situation for the School of Computer Science & Mathematics at Victoria University. The impact of poor student enrolments has had upon computing curricula is described along with the various interventions undertaken to alleviate the problem. The paper outlines the challenges we faced during the process, the rationale for the proposed response and the consequent alignment of the computing curricula.

Current Challenges in Computing and IT Programs

Worldwide there remains a strong job market and high demand for computing professionals (Liu, 2007; Melymuka, 2006). In the United States, Dychtwald, Erickson and Morison (2006) in their book *Workforce Crisis: How to Beat the Coming Shortage of Skills and Talent* have predicted an impending IT workforce crisis for the coming decade due to the declining enrolments in both undergraduate and graduate IT programs. In Australia, where the ICT industry generates revenues of AUD 65.7 billion (USD 60 billion) or 8.7 % of GDP, the federal government has identified the shortage of IT students as an issue requiring remedial action in the near future. Likewise in the State of Victoria, the second largest provider of ICT skill in the country, government continues to invest in possible countermeasures to steady the decline of skilled workers in the IT industry (MMV, 2004).

If computing is such a vibrant field, then why does it not attract students to ICT tertiary studies? According to the ICT Skills Research report, the most positive aspect of the ICT career is the opportunity to work with the latest technologies (MMV, 2007). Amongst American IT programs, Finkelstein and Hafner (2002) identify the existence of a professional practices gap in that the programs do not prepare students sufficiently to cope with the practical challenges in current technologies adoption. Additionally, it is widely recognized that computer science undergraduate studies do not adequately prepare students for proficiency in the workforce where they need strong communication skills and business aptitude (Taft, 2007). United Kingdom employers want graduates with technical knowledge, intellect, and a willingness to learn (Harvey, Moon, Geall, & Bower, 1997), whereas in Australia research on employer satisfaction with graduate skills has found that computer science graduates lack problem solving and business communication skills (AC Nielsen Research Services, 2000). It has also been argued that students are not going into computing courses as they cannot relate course content to specific occupations. A Finnish study of staff and student attitudes to the computing discipline noted that students were more interested in how computing related to business than were their lecturers (Ylijoki, 2000) and there is a need to showcase exemplars of qualified people working in IT to students (Victoria University [VU], 2007).

Yet the mission of the universities is to educate and prepare students to be universal lifelong learners, rather than to prepare them for job specific tasks. Given the reality and the necessity for any academic program to be sustainable, it has to have students enrolled. Therefore, it is essential that any IT program should focus on the balance between vocational and intellectual demands in order to enhance graduate employment prospects. The curriculum should ensure that students are prepared effectively for future employment by responding to the education and training needs of industry and the community. Computing programs wishing to attract students need to have specialized studies that are of industrial strength and are updated regularly to reflect the progress in the discipline (Finkelstein & Hafner, 2002; Lui, 2007).

Without question the most significant challenges with respect to the design of IT curricula relates to the objectives of excellence and relevance. The engagement with industry and the community is required to determine the relevance of the program to meet their needs in the future. As well, external factors such as government funding for higher education, university and faculty strategic plans, domestic and international student demand, and professional accreditation demands, all come to bear upon academic decisions for program development (Tan & Venables, 2007).

Our Situation

Given the impetus to be financially independent, the greatest challenge for the School of Computer Science and Mathematics at Victoria University, Melbourne has been the steady decline in both local and international student numbers across the board in all of our courses. This has occurred despite the anecdotal evidence of a growing local demand for computing graduates and the growth in IT program offerings. To arrest this decline and to remain competitive, our course offerings have undergone several major revisions in recent years.

Historical Perspective

Prior to 2004, the School of Computer Science and Mathematics enjoyed strong student demand for each of its three core undergraduate courses: Bachelor of Science in Computer Science, Bachelor of Science in Computer & Mathematical Sciences, and the Bachelor of Science in Computer Science and Aviation which attracted students both onshore and offshore (in Hong Kong, China and Malaysia). Since then, several factors, such as the early symptoms of the decline in student numbers, changes in national legislation, the meeting of University requirements and the need for professional body accreditation, have triggered what seems to be unending rounds of course restructuring and documentation at our institution.

Up until 2003, the local student numbers had remained steady for a number of years while our offshore programs continued to grow. In 2004, concern was raised when local student enrolments failed to meet the targeted enrolment numbers. Subsequently, a review of our existing offerings was made with the view to attracting new students, and various specializations of our traditional computer science programs were seen to hold promise.

Firstly, the rapidly developing field of internet technologies was seen as a priority area that would be attractive to new school leavers and overseas students. A new program was proposed to include topics on web data management, web-based services, and internet applications. As well, an additional program where students develop IT specialist skills and the conceptual understandings to design, install, configure, and manage various advanced data management technologies was proposed. Finally, to capitalize on our in-house expertise, a program coupling both computing and mathematical sciences with a focus on finance and risk management was designed to capture the niche market of financial computing mathematics. There is no other undergraduate course in Australia and, indeed, very few internationally, that seek to combine finance with both disciplines of computer science and mathematics. As a result, three additional undergraduate programs - Bachelor of Science in Information Technology, Bachelor of Science in Internet Technologies and Applications and Bachelor of Science in Computational and Financial Mathematics - were scoped and then documented before their introduction in March 2005 (VU, 2005).

In parallel with the introduction of these three new programs, a major course review was undertaken to comply with the Australian government's Higher Education Support Act (HESA) 2003. This legislation mandated and regulated the conditions under which tertiary institutions were able to be run and funded. It impacted all Australian universities, resulting in Victoria University adopting a uniform system for unit sizes and associated credit points across all program offerings. For our undergraduate programs, an extensive academic review revealed no uniformity in the unit values within and across year levels, and it exposed inconsistencies in the number of units for different year levels within the degrees. The adoption of the HESA compliant model necessitated the retrofitting of existing programs so that they could be collapsed from 29 units of study to 24 whilst maintaining the overall the breadth and depth of syllabi. The first implementation of the new HESA compliant programs took effect for the academic year commencing in March 2006 (Tan & Venables, 2007).

In addition to meeting HESA requirements, the University itself has placed considerable pressure upon our program offerings by insisting that each program be financially sustainable in both onshore and offshore deliveries. To police this requirement, regular extensive program reviews are scheduled that examine the demand and the viability of each course offering, together with the contents, for relevance and appropriateness to the different student cohorts. All Schools are expected to rationalize their programs by merging any that are similar. Additionally, content is examined for compliance with internal university policies, for instance, the embodiment of core graduate attributes that must be developed progressively throughout the curricula (Miliszewska & Tan, 2004).

All our courses came due for professional accreditation through the Australian Computer Society (ACS) in 2006. The ACS is the professional body responsible for the assessment of all higher education ICT courses accreditation ensuring international credibility and enhancing the marketability of programs (ACS, 2003; Ramakrishnan, 2007). Based upon the American Association for Computing Machinery (ACM) models, an ACS accreditation's overriding task is to examine all aspects in the provision of a quality ICT education program designed to produce competent graduates. The three main foci of assessment are the structure and content of curricula, the resources of the teaching and learning environments, and the quality assurance processes in place at the university (ACS, 2003). The key steps included collection of data, completion of a suite of ACS documentation templates by the School, and the assembling of an assessment panel by the ACS, followed by the panel's site visit and the final report of the ACS recommendations. Although the accreditation was not in itself a full review or audit of courses, it did help identify key areas that needed immediate attention and some forward planning.

The various restructurings, reviews, and assessments of the academic programs throughout the years from 2004 to 2006 have entailed enormous amounts of goodwill, time, energy, and dedication from staff of the School of Computer Science & Mathematics who volunteered their time without adjustments to course loads. In retrospect, the introduction of the three new programs along with the changes made to content in units of study did little to arrest the decline in applying students.

Moving forward with no immediate increase in student demand in sight, it became apparent that we had too many programs with too few students to ensure long term sustainability. A critical reappraisal of our situation was needed for survival. An immediate short term strategy of pruning existing units of study offerings was done and in the longer term, a radical computing curriculum review was called for to tap new local and international markets for students. In a nut-shell, a total curricula review was undertaken to find a program structure that would translate into an increase in student numbers

Current Perspective

In response, an analysis of the local situation was made in comparison to computing course offerings worldwide. Our researches found, perhaps not surprisingly, that successful programs seemed to be able to differentiate themselves from their competitors by fulfilling the needs of the community and by meeting their expectations (Novotny & Doucek, 2007; Sharda, 2007). Suggested avenues for exploration were successful programs at other institutions in interactive digital media, cross disciplinary applications like health informatics and embedded systems informatics, entertainment technologies, and game development (Clemson University, 2007; Monash University, 2007).

Locally, we sourced advice about possible future curricula directions through our Course Advisory Board, which is comprised of industry representatives, professorial academic staff from other institutions, and our senior academics. To gain insights into future students' preferences for tertiary studies we have relied heavily upon a set of investigations and reports conducted at a state funded level by Multimedia Victoria (MMV, 2004, MMV, 2007).

The mission for the course development team was to derive a new and innovative program structure that would prove attractive to potential students as our immediate concern was to increase our student intake. The proposed program would need to embrace emerging computing paradigms based upon sound academic principles and be able to operate within the existing budget constraints.

The Response

With the immediate economic need to reduce the number of program offerings but still provide prospective students the opportunities to acquire different knowledge and skill sets, a decision was made to merge the current five existing courses (SBCO, SBIT, SBIA, SBCA, and SBCF) into one main program. The program, to be named Bachelor of Applied Science in Computing, would have six specializations built within the structure. For the proposed program, there would be a noticeable shift in emphasis from our traditionally theoretical offerings to a program with a more practical orientation necessitating the addition of the word 'Applied' to the name of the award. In the new structure, specialized studies to be offered are: a) Interactive Digital Media and Game Development, b) Web Technologies and Mobile Computing, c) IT Security, d) Computational Finance, e) Business Intelligence and Service Computing, and f) Aviation Technology.

The choice of specializations was made firstly to incorporate the major characteristics and paradigm shifts in the ICT industry, secondly to cater for the broad diversity of student interests, and thirdly to capitalize on our historical strengths. The revised course structure addresses the issue of accommodating the latest developments in the areas of ICT with the inclusion of specializations that allow students to progress to the top four ICT career options that students are interested in: game developer, graphics designer, Web or multimedia designer, and Web developer (MMV, 2007, p. 24). As well, there have been forecasted future skill shortages for the ICT specializations of security and in business applications and service computing (Australian Workplace, 2007). Further, the computational finance stream combines statistics and computing with a focus on finance and risk management, and in overseas markets like China graduates are sought with this combined expertise. Locally, aviation and computing studies combined have historically been a good attractor for students, and therefore the aviation technology stream capitalizes upon this interest.

The proposed Bachelor of Applied Science in Computing program structure, as detailed in Table 1, comprises a total of 24 units of study over a three year program. Notice that, irrespective of a student's choice of specialization, there are 15 common units that must be undertaken. For program completion, the remaining 9 units complete the specialization studies of a chosen stream. In each stream, there are a set of stream required units of study together with some stream suggested electives. For program completion, it is understood that a student will pass the 15 common units together with the required units of their stream specialization and any necessary electives to total 24 units of study overall. The specializations for each stream are listed in Table 2.

For economic reasons, it was critical to streamline the number of units that could be offered in the new proposed structure without sacrificing the breadth of coverage of the combined programs. From an administrative standpoint, having all students study a set of common core units means that class sizes become more viable. As well, amongst the specialization streams it should be noted that required units of study in one stream may also be used as suggested electives in another stream, again underlining that the need to cater for the diverse interests of our potential students within current financial constraints.

Table 1 –Proposed Bachelor of Applied Science in Computing program structure

Semester 1	Credit Points	Semester 2	Credit Points
Year 1			
RCM1115 Comp Systems and Architecture	12	RCM1113 Multimedia Systems	12
RCM1311 Programming 1	12	RCM1312 Programming 2	12
RCM1613 Applied Statistics 1	12	RCM1713 Computer Algorithms	12
RCM1711 Math Foundations	12	One elective	12
Year 2			
RCM2211 Database Systems 1	12	RCM2111 Data Communications & Networks 1	12
RCM2311 Objected Oriented Programming 1	12	Stream required unit	12
RCM2312 Software Engineering 1	12	Two electives	24
One elective	12		
Year 3			
ACE3145 Professional Communication	12	RCM3002 Project 2	12
RCM3001 Project 1	12	RCM3111 Modern Computer Networks and Pervasive Computing	12
Two stream required units / electives	24	Two stream required units / electives	24

Table 2 –Required and elective units for stream specialization

Interactive Digital Media and Game Development	Internet Technology and Mobile Computing	IT Security
Stream Required Units: RCM2213 Computer Graphics and 3D Modelling RCM3112 Human Computer Interaction and Game Development RCM3970 Computer Graphics for Game Programming RCM3980 Virtual Reality and Smart Environment **Suggested Electives:** RCM3312 Intelligent Systems RCM3313 Quality Assurance and Software Testing	**Stream Required Units:** RCM2930 Game Engines and Online Games RCM3950 Development of Web and Mobile Applications RCM3820 Web Computing and Services RCM3960 Internet, Wireless and Computer Security RCM3980 Virtual Reality and Smart Environment	**Stream Required Units:** RCM2112 Operating System and System Security RCM3720 Cryptography and Computer Security RCM3960 Internet, Wireless and Computer Security RCM2511 Image Processing and Pattern Recognition

Computational Finance	Business Intelligence and Service Computing	Aviation Technology
Suggested electives: RCM2612 Financial Data Analysis and Forcasting RCM2915 Practical Financial Optimization BEO2*** Technical Analysis and Trading Rules of Financial Instruments (appropriate unit numbering to be decided) BAO1101 Accounting for Decision Making BEO1103 Microeconomic Principles BEO1104 Macroeconomic Principles RCM3413 Financial Engineering RCM3911 Financial Simulation and Applications RCM3940 Financial Risk Analysis and Modelling BAO3307 Corporate Finance BAO3402 International Banking and Finance BAO3403 Investment and Portfolio Management	**Stream Required Units:** RCM2218 Enterprise Database System and ERP RCM3311 Enterprise Information System Development RCM3115 Enterprise Wide Computing and Service Computing **Suggested Electives:** RCM3950 Development of Web and Mobile Applications RCM3820 Web Computing and Services	**Stream Required Units:** RCA1010 Introductory Aviation RCA2020 Meteorology and Human factors for the CPL RCA2030 Navigation and Flight law for the CPL RCA2040 Aerodynamics and Aircraft General Knowledge for the CPL RCA2060 Operations Performance and Flight Planning for the CPL RCA3010 Instrument Rating (IREX) RCA3030 Meteorology and Human Factors for the ATPL RCA3040 Flight Planning, Navigation and Air law for the ATPL RCA3060 Aerodynamics and Aircraft Systems for the ATPL

Curriculum Differentiation

The new proposal preserves one of the historical strengths of all our original programs - the industry based final year computing project units. These capstone projects give students the opportunity to work on a real-life software development tasks where they experience the practical challenges of building software systems whilst appreciating the needs of a business client. In this environment, students not only need to use their technological knowledge but also need to develop their communication, teambuilding, and problem solving skills. When dealing with clients, students develop negotiation and listening abilities, and they hone their presentation and marketing skills.

At the same time, the program allows the School to offer units that capture the most likely needed skills for graduates in the near future. Brandel (2007) identified that the most demand for skills will be in the area of machine learning, mobilizing applications, wireless networking, human-computer interface, project management, general networking skills, network convergence, open source programming, business intelligence, embedded security, .Net, C++, and Java. This view is reinforced by a report of the Australian Workplace (2007) which identified skills in demand that are also covered by our structure. These skills include Oracle, data warehousing, C++, Java programming, J2EE, .Net technologies, ASP, security, and risk management.

Another consideration in designing the new proposal was an awareness of the academic rigor as required for ACS accreditation of our program. For marketing purposes, both locally and internationally, it is crucial that graduates satisfy the requirements of a professional level of accreditation, thereby enhancing their employment outcomes.

Conclusions

The computing programs at Victoria University continue to face the same local, national, and international challenges as do other higher education providers of IT programs within Australia as it strives to maintain relevancy in its program offerings. Due to external factors, including the decline in student demand, the School of Computer Science and Mathematics has found itself in a more precarious position financially. University procedures have illuminated inefficiencies with respect to class sizes and individual academic workloads, and it has become imperative that a strategy be found to turn round the financial situation. Recognizing the major drivers for change in its curriculum and identifying its strengths, weaknesses, opportunities, and threats in the recent computing curricula review is critical to the future survival of its computing programs within the School.

The question remains, will the above proposed structure lead to an increase in student demand? The success, or otherwise, is heavily dependent upon an increased market presence. To this end, School academics have recently become more actively involved in the promotional activities locally and abroad. For instance, specialized bilingual brochures have been developed to specifically target offshore cohorts and relationships with local feeder high schools continue to be nurtured. With adequate marketing, it is hoped that the proposed new structure will allow us to respond quickly to external positive changes in demand and thus attract students to our programs.

The information we have from our researches from our staff networks have supported the adoption of the new program structure. It has been reported that game development courses in other universities have very good intakes (Metlikovec, 2007), which supports our belief that there is strong student interest for streams in Interactive Digital Media and Game Development, Web Technologies and Mobile Computing and IT Security. In fact, it is hoped that they will become the flagship offerings for the School. As well, we expect to further expand our offshore activities and become more involved in the expanding Chinese education market and expect that the Computational Finance stream will be very attractive to this clientele. This stream in Computational Finance uniquely differentiates us from other Australian universities as does our Aviation Technology stream. As well, forecasted industry shortages in security and in business applications and service computing should convert to increased student interest in careers in these areas. The proposed program aims to increase student intake; however, staff realize that little can be done about cyclical and global forces that impact considerably upon our situation. In this instance, staff wish to remain in charge of their own destiny as to do nothing would be no more risky than leaving the School's future in the hands of University administrators.

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