What Drives Curriculum Change?

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Abstract

While promotional literature about computer science programs may claim that curricula are determined by the needs of the students and by international best practice, the reality is often different. In this paper we reflect on the factors underlying curriculum change in computer science departments and schools, from institutional requirements and financial pressures to purely academic considerations. We have used these reflections as the basis of an investigation of curriculum management practices at institutions in Australasia, via a survey instrument sent to a range of colleagues. Our findings from the survey are consistent with our own experiences, namely, that curriculum change is driven or inhibited by factors such as vocal individuals and practical constraints rather than higher academic motives.

1 Introduction

Throughout Australian and New Zealand tertiary institutions in recent years, the pressure for change has become a constant. We compete for international students, respond to changes in funding models, amalgamate or break away from other departments, and adopt new methods for delivery of teaching. In computer science, we have been faced with a dramatic fluctuation in the demand for our graduates – in addition to the dot-com boom and bust, there have been the pressures of the Y2K scare and (in Australia) introduction of the GST – while the technology of computing and communications continues to develop at a rapid pace.

There are a great range of pressures on our curricula (Tucker 1996), and we observe that our curricula are indeed changing. The most obvious of these changes is (in the years up to 2003) addition of a range of postgraduate coursework programs at virtually every institution with which we have contact. Change is also evident through the increased specialization of the qualifications we offer, and through the specific subjects available. While COBOL, assembler programming, and numerical methods have declined in significance, for example, web programming and distributed systems subjects have become commonplace.

In this paper we discuss catalysts for change. Our aim is to identify possible factors that have significant influence on curriculum change. To achieve this aim, we have first drawn upon our own experiences and sketched a ten-part framework of potential influences to evaluate within the current tertiary sector environment. Then we have surveyed colleagues from across Australasia to determine the extent to which, in their view, each of the ten factors was a determinant in decision making in their Department.

The responses were unequivocal. The main driver of every category of change was the opinion of influential or outspoken individuals. Major changes were driven as much by academic fashion, financial concerns, and student demands as by academic merit. External curricula were virtually irrelevant. Only for changes within an individual subject were pedagogical concerns dominant. Participants overwhelmingly considered the curriculum changes successful, in that they had achieved the goals they had articulated at the beginning of the process, and changes had on the whole stayed in place.

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2 The curriculum and types of change

To define the aim of the curriculum, Henkel & Kogan (1999) find it convenient to distinguish between programs designed to satisfy "academic" objectives and those designed to satisfy "vocational" objectives (although the two of course are not mutually exclusive). Correspondingly, they find two models for curriculum *organization*. Emphasis on academic objectives tends to lead to the "individualistic" curriculum, characterised by a loose coupling of subjects, choice for students and staff, and little concern for vocational skills. "Staff are free to offer options whether or not they link with other elements of the curriculum: these will typically follow research interests. Curriculum development is ... discipline-led, incremental, strongly influenced by student demand and staff preference." Conversely, emphasis on employment objectives tends to lead to the "directed" curriculum, with an emphasis on course design and coherence. Henkel & Kogan (1999) observe that "teachers' freedom is limited since courses must link in a coherent way. Curriculum development is ... course-led, systematic, and less influenced by individual objectives."

Our discipline is arguably near the intersection of these two models, with a strong individualistic influence from computer science's mathematics heritage, and a moderating directed influence from the areas of software engineering and, more recently information systems.

The first ACM proposal for a computing curriculum was published in 1968, and in the 35 years since, we have seen rapid changes. Goldweber, Impagliazzo, Bogoiavlenski, Clear, Davies, Flack, Myers & Rasala (1997) give a detailed, interesting account of the development of the curriculum up to 1997. Pham (1996) discusses the computing and information technology curriculum in

The following are the broad categories of curriculum change that we are investigating:

1. Introduction of a whole new degree program or specialised stream at the undergraduate level.
2. Introduction of a whole new (course-work) degree program at the postgraduate level.
3. Introduction of a new subject, or deletion of an existing subject.
4. Change to or within a first-year or other core subject, such as a change to the first language taught to undergraduate students.
5. Change to or within an elective subject, such as a change in the choice of AI language used in a third-year subject.

Figure 1: *Types of change. This text formed part of our survey distributed to academic colleagues in Australasia.*

Australia and argues that, while curriculum discussions in the eighties were mostly about choice of programming languages and how to teach problem solving, the nineties brought a "paradigm shift in IT development" which transmuted curriculum debate. As IT was "used as a driving force to enhance and transform work practices in most sectors, it [became] more necessary to provide graduates with other skills besides highly technical computing skills." Additionally, government "placed demands on higher education systems to cater for a mass clientele, instead of a small elite section of the community as in the past," and this in turn posed considerable challenges for existing practices. Finally, the emergence of new technology, primarily in the fusion of communications and information technologies, called for radical changes to syllabi.

We can add that in the same period, the nineties, the most radical change in the landscape of computing programs has no doubt been the appearance of coursework masters programs. Some of these were clearly designed as re-training programs for people with proven study skills from outside our discipline, while others were designed as extensions to undergraduate computing programs, often intended for international students.

Hence change has been pervasive, and at many different levels. A broad variety of changes take place in computing curricula, ranging from those that are almost trivial through to the introduction of complete new degree programs. Figure 1 summarises five different points in this spectrum. The descriptions given in Figure 1 are exactly those used in our survey instrument, described shortly.

The literature on curriculum changes in tertiary education focuses mainly on larger-scale transformations that fall outside of our scale. Much of the academic discussion is concerned with the changes in teaching culture and philosophy that accompany a wholesale move away from traditional (subject-based, knowledge-centered, teaching-focused) approaches, when institutions turn to alternative (student-based, competence-centered, learning-focused) approaches that stress the educator's role as a facilitator of learning, rather than a transmitter of knowledge (Bocock 1994, Huba & Freed 2000, Jones 2002, Merton, Clark, Richardson & Froyd 2001). This kind of global transformation will inevitably involve all academic staff in a department, even if introduced incrementally. Our focus in this paper is on more local changes: the types listed in Figure 1 could (and often will be) implemented by a small group of people.

Small local changes are usually approved and implemented with a minimum of debate. For example, subjects are sometimes "rested" in a particular year while a staff member is on long service or study leave. This kind of decision is typically made by a Head of Department, or perhaps a small committee of staff administering the particular program. The formal approval process within the University for such a change is usually reasonably streamlined, and one-off amendments to published guidebooks can sometimes be made just a few weeks before the subject is scheduled to commence.

Changes within a subject may require even less formality. In many institutions staff are reasonably free to design the content of the subjects they teach, so long as broad criteria of topicality are met. It is often the case that a staff member who has recently moved between institutions or is teaching a subject for the first time may radically change how it is taught, or the tools or languages used in practical work, or the range of issues taught in a particular topic. Indeed, such change is seen as an important element in renewal: having the same staff member deliver the same material for too long a time may lead to it becoming stale or irrelevant. The content of subjects may be reviewed or approved by a senior staff member – if such approval is sought. For core topics, however, where change can have implications for subsequent subjects, a broader group of staff is usually involved.

At the other end of the spectrum, introduction of a new degree program may involve marketing studies, business plans, formal approval processes that involve an Academic Board or Senate, and, if the program is to be available to students entering from secondary school, several years of lead time for prerequisite requirements to be propagated through handbooks and government-administered educational bodies.

3 Change processes

Ewell (1997) suggests that most curriculum changes are implemented piecemeal, and, in fact, "without a deep understanding about what collegiate learning really means and the specific circumstances and strategies that are likely to promote it." Ideally, according to Lachiver & Tardif (2002), curriculum change is managed in a logical five-step process:

1. an analysis of the current offerings and context;
2. the expression of key program aims in a mission statement;
3. a prioritization of resources and development strategies;
4. the implementation of the targeted curricula change; and
5. the establishment of monitoring tools and processes.

Our perception is that the messy realities associated with change are somewhat different to this ideal.

In the first three authors' department, at the University of Melbourne, most curriculum change initiatives come from a small cohort of senior staff, but they are usually canvassed by a Teaching Committee and discussed widely. Hence there is a sense of shared ownership of changes. It would, however, be fair to say that the collegiate decision-making process is primarily applied to smaller changes, and that large changes – such as the introduction of new postgraduate coursework programs – tend to be driven and implemented by a small number of individuals.

In the fourth author's department, at RMIT University, the processes for implementing curriculum change have many contrasts to those of the University of Melbourne. Some of these are due to the fact that programs offered in RMIT's School of Computer Science and Information Technology have significant structural constraints. First, there are many more academic staff, making processes based largely on collegiality difficult to implement. Second, the same programs are taught by different staff on two campuses, using the same lecture notes and assessment materials. Third, many subjects are components of multiple programs, and may be taught in different modes, such as daytime for undergraduate students and evening for diploma students. Fourth, the same programs are also offered both online (for example, through Open Learning Australia) and off-shore. Offering a new elective subject on one of RMIT's local campuses is straightforward, but changing the core curriculum has wide ramifications.

Curriculum changes at RMIT are managed primarily through a hierarchical process. Each subject and discipline-related group of subjects is owned by a group of academics who are responsible for ensuring that content is appropriate, and who recommend changes such as addition of a subject to the group. A committee of program coordinators or a committee of senior staff decides which changes to approve. Changes can also originate with the Industry Advisory Committee (whose members are industry professionals), the main role of which is to review the School's offerings. More significant changes, such as addition of a new program, are decided by senior staff.

We do not have experience with the kind of wholesale change of teaching philosophy and culture mentioned in Section 2. However, it is clear that such major change needs to be introduced with great care. Bocock (1994) discusses the impact of radical change on staff and argues that for such change to be successful, professional, including pedagogical, training must be taken seriously. Froyd, Penberthy & Watson (2000) point out that there are important lessons from organizational theory which need to be learned if success is to be likely, and if change is to be sustainable. Compared to the literature on curricular innovation, little has been published about curricular change processes. Froyd et al. (2000) propose an eight-step "organizational change model" for curriculum reform.

4 Factors influencing change

To begin our study, we reflected on the range of curriculum revisions that we had been involved with, and identified ten factors that had acted as influences on the way that proposals for change had been received in our departments.

In this section we list these ten factors, and explain the ways in which we perceive them to have been drivers or inhibitors of change. The factors are summarised in Figure 2, showing the terms in which they were described in our survey.

A. Influential individuals Lachiver & Tardif (2002) explain key factors for change within their department. The first factor initiating change, they write, is strong leadership accepted by the academic staff. The key characteristic of such leadership is to have the capacity to attract other academic staff to rally behind principled educational objectives that are supported within the environment. The second factor is sharing and accepting the need for change, a point that is often stimulated by noting the discrepancies between the current output and what is desired by employers. The extent of a curricular change, whether wide-scale or minor, is a third factor. Finally, because many academic staff hold embedded teaching and professional practices, the degree of flexibility for departmental staff is seen as the final factor.

The following are the factors affecting curriculum change that we hypothesise are significant:

A. Influential or outspoken individuals.
B. Financial pressures, including resource availability.
C. Staff availability or workload.
D. Employer or industry viewpoints.
E. Current or prospective student viewpoints.
F. Student abilities or limitations, or intake considerations.
G. Pedagogical argument, or academic merit.
H. University or Government requirement or regulation.
I. Professional accreditation needs, or syllabi set by professional bodies.
J. Academic "fashion", including the desire to remain in step with other institutions.

Figure 2: *Factors influencing decisions about curriculum change. This text formed part of our survey to academic colleagues in Australasia.*

In our experience, decisions that affect whole departments and degree programs are often taken by a relatively small core of senior staff. Of course, these staff usually have a considerable depth of experience, and are typically the ones that are in tune with institutional policies and politics. But it is also possible for decisions to be unduly influenced by staff with strong opinions over, for example, programming language choices. Academic courtesy (and apathy) sometimes means that the outspoken individuals do not get contradicted, even when they are wrong. Ideally there are informed people arguing both sides of any proposed curriculum change, and we are all better for the consequent debate.

Watson (1994) suggests that key individuals have so much influence because of a lack of alternatives: the pace of change required by departments to keep up leaves little room for mistakes and reflection. With the rise in "cult of personality", managers may then neglect the fact that they are stake-holders in the effectiveness of curriculum change.

B. Financial pressures Clearly there are powerful budgetary forces that influence our decisions. Team-oriented project subjects are arguably one of the most important parts of a computing education, particularly for those graduates who are to work in the software industry. But they are disproportionately expensive to mount, and so are sometimes quota-ed or otherwise controlled.

Class sizes are a consequence of the financial stringencies we operate under. At our institutions, first year subjects are taken in lecture groups of several hundred students, and tutorials are largely taught by sessional staff. So students who are new to the University face daunting challenges, at exactly the time when all reason would suggest that they need to be building relationships with experienced academics. A reminder of this imbalance is the

steady stream of students who come asking for referees' reports in connection with, for example, study abroad applications or workplace-based studentships. The best that we can usually do for them is to write "supported" on the application and sign, since we do not have any personal knowledge of their aptitudes or abilities. Smaller classes would greatly improve the lot of the average student, and enable them to build a personal relationship with at least one staff member. That relationship might then help ease some of the performance anxieties felt by students, and the consequent temptation to submit work that is not their own. Indeed, one of the most telling observations made by our graduates is that in the time they were with us, they didn't really get to know any member of the academic staff. Conversely, a surprisingly high proportion of the students that do manage to build a relationship with a staff member will continue to higher degrees, and one wonders how many potential researchers are leaving university simply because they have not had a chance to appreciate its benefits.

The use of sessional staff also means that proposals for change must be filtered through the sanity check of "will the sessional tutors be familiar with the material?" Ten years ago when the University of Melbourne moved to teaching a functional language in first year, availability of suitably qualified sessional staff was a major potential stumbling block, and a special training program was run.

Cost pressures can influence issues other than staff ratios. For example, a department or school might not be able to afford a site license for some software that students should perhaps experience, and so teach it at arms length in lectures; similarly, a department might consistently allocate their oldest computing facilities for undergraduate use. This then might make it hard to run the most recent versions of software, or to assign project work of the desired complexity.

Another way in which financial pressures show is in the choice between three-year programs and four-year programs. Most of us believe that our four-year programs provides the higher-quality education. But four-year programs cost more, and so we supervise compromise programs in which students do not always have the opportunity to fully refine their skills before entering the workforce.

C. Staffing issues, including workload We have commented on financial matters, and the effect that they can have on curriculum decisions. But even if funding for staff positions is available, it is not always possible to fill them. It is likely that most academics all been in the position of being asked at short notice to teach the database subject, or the AI subject, or the theory course, because a colleague has resigned, or a position that has been advertised has not been filled.

Staff shortages can mean that we narrow the range of subjects offered. One of the perennial decisions we face is best summarised as this: we identify a clear area of computer science that we do not cover, and probably should, and start talking about a new subject. But then someone asks who is willing to add to their teaching load to design and offer this subject, and the room falls silent. Many of our curriculum decisions are based upon the zero-sum policy, and if new material is to be included in particular year levels, then something else must be removed.

Surplus staff are a related issue. How many departments, we wonder, have continued teaching of outdated assembler languages simply because it was a skill of a particular staff member?

D. Employer and industry viewpoints While the professional bodies ultimately reflect employer and industry expectations, these pressures are also sometimes directly exerted. For example, at one stage the concentration of defence contractors in Adelaide made Ada a "desirable" programming language in South Australia, and degree programs were revised to reflect this factor.

Many Departments and Schools have an industry advisory committee, to allow a timely flow of such advice and suggestions. The success or otherwise of such committees is heavily dependent upon the energy and time that the industry representatives are able to bring to the task.

There is much anecdotal evidence that employers have strong opinions about the curriculum, usually requesting more emphasis on transferable skills (such as communication, social, analytical, and critical-thinking skills) in graduates, while feeling that these requests are not heard. For example, Jones (2003), citing the cover story of the May-June 2003 ASEE Prism, writes that

> educators are struggling to prepare well-rounded engineers for today's workplace. Stimulated by the broadening required in ABET's Criteria 2000, engineering educators have been overhauling or tweaking their curricula. But employers are complaining that change is not happening fast enough, in critical areas such as communication skills. University officials explain that many institutions are research based, and thus concentrate curricula on more theoretical work. And crowded curricula and scarcity of resources to implement changes contribute to the slow progress.

E. Student viewpoints Students often assert that they are not customers; nevertheless, the customer is the one spending the dollar, and can sway decisions. The University of Melbourne used functional programming languages as the first teaching language for nearly a decade, a choice made on the grounds of academic merit. However the staff teaching these subjects felt obliged to defend that choice to students, who saw their high school peers learning other more mainstream languages in their first semester at other institutions. In part because of these concerns, the first language was recently changed to C.

Part-time students present complex issues. These students strongly prefer evening classes. At many universities, this means that there are only a limited number of one-hour slots (perhaps eight or ten) into which lectures can be scheduled for these students, compared with forty such slots during the day. If the number of days on which students need to attend is to be minimised, the options are even more limited. At the same time, these students expect a good range of elective subjects to be offered, with the result that on any given evening three to five subjects are running simultaneously. Furthermore, at RMIT University, students can commence in either semester (or indeed in the summer) and progress at wildly varying rates – completing anything from one to ten subjects per year. The scheduling difficulties can lead to compromises in the structure of prerequisites and affect decisions as which material is core.

Student opinion is informed by the mass media, and by the opinions of parents (also often derived from the media). Extensive negative coverage of the IT slowdown had a marked effect on computing intakes in 2003, even though students commencing in 2003 will not graduate until the end of 2005, or later.

However, on the whole, student demands appear to be a limited influence on curricula. British cross-disciplinary surveys suggest that "student preferences do not tend to push the curriculum either to more academic or to more vocational treatments" (Henkel & Kogan 1999), and that student choice continues to be determined primarily by personal interest.

F. Student abilities In an ideal world, our programs would be dictated by our desires to create graduates of the highest possible calibre. And, were we capable of sourcing the correct raw material in sufficient quantity, perhaps we could achieve that goal. Unfortunately, the exigencies of filling quotas for both local and international students mean that the weaker students in our intakes sometimes do not meet our expectations in terms of maths or English skills, or in breadth of knowledge in other ways. Sometimes we take the path of least resistance, and design our curricula not for the excellent students that we remember many years later, but instead for the mediocre ones that muddle their way through our degree programs, never excelling and sometimes failing.

Of course, many of the mediocre students go on to make great successes of their lives, and generate innovations and software that is valued by the community. But consideration of their needs, and application of those considerations across the gamut of student abilities, also means that we do a disservice to the truly excellent students.

G. Pedagogical argument, academic merit Many changes are proposed because they are an indisputably "good thing". One would find it hard to argue, for example, that the introduction of laboratory classes into a first programming subject that had previously been based solely upon lectures and tutorials was not a "good thing". Similarly, we imagine that most readers would accept without question that third-year or fourth-year project-based subjects are indispensable for students going into the computing industry.

Most of our degree programs contains these two features, of course. No less desirable would be lecture groups limited to at most (say) 100 students, and one-on-one mentoring to help students to learn difficult concepts. These two can also be defended in terms of academic merit, yet our degree programs do not typically include these features, and there are strong factors at work that prevent their adoption.

For some decisions, the relevance of academic merit is unclear. An example where pedagogy is relevant, but only somewhat, is whether certain subjects should be core or elective; we have all been involved in disputes as to whether a topic such as advanced algorithms is fundamental or merely important. An example where pedagogy is arguably irrelevant – although opinions are certainly strong – is choice of a tool for teaching in a database subject. A case could be made for Oracle (widely used, powerful, integrated with design tools, well supported), Access (limited functionality but available on every desktop), or MySQL (an archetype of public-domain software). An interesting case study could be made of Visual Basic, which is not widely taught, yet for many years has been a dominant language in industry, and (as a database programming language) has interesting properties that the popular teaching languages do not. While serious criticisms can be made of Visual Basic, many of them apply equally to languages such as Java that academia has accepted (Irimia 2001).

H. University and government regulation University administrations increasingly push the case for efficient use of resources. While the number of programs offered in our discipline has been growing for a long time, and the closing down of programs is uncommon, there is usually considerable pressure to discontinue low-enrolment subjects. At the University of Melbourne, we have recently found it necessary to cancel a specialist subject targeted at combined computer science-law students, to avoid budget penalties; and last year similarly ceased teaching a "research frontiers" subject at the second year level that was intended to enthuse highly-able students. At RMIT University, similar pressures led to progressive withering of the stream of AI subjects.

Such pressures can have impact on teaching methodologies in general, and many of us have been exposed to pressure to remove practical classes in some specific subject, or to remove tutorials altogether. The dislike within universities of employing large numbers of sessional staff – a practice that the unions note is open to exploitation – is a potential further constraint on teaching practices.

In IT departments there can be tension between the desire to provide computing facilities tailored for IT students, the availability of generic (and often inappropriate) facilities provided by the university, and lack of university understanding of the specific needs of IT students. Computer science departments come under pressure to cut their expenditure on facilities that the university sees as an unnecessary replication of alternative services. Given the pressures on budgets, it may be tempting to use university facilities, but they could not be used for teaching of many of our subjects.

Universities wish to be perceived as forward looking. During the 1990s, there were widespread moves to make subjects and programs available online, and to bundle teaching materials for licensing to other institutions. Online teaching was to be of the same standard as that available on campus; and, despite problems such as the difficulties of long-distance invigilation, at some universities student transcripts do not distinguish between online and on-campus offering of the same subjects. Such factors can be a strong influence on curriculum, for example through staff not attempting to teach material that is difficult to translate to an online delivery mechanism.

Another source of pressure is university administration's insistence on internal, national, and international benchmarking. We compete for students with other Australian institutions, and those same students then compete for jobs with the students from other institutions. Moreover, we may also be required to show that our graduates compete with those produced by the best US universities. At a more immediate level, failure rates are compared between disciplines, but such comparison may be inappropriate. In the arts and traditional sciences, students are required to show an aptitude for those specific skills in secondary school; but programming is not taught until university, and it is unsurprising that a fraction of students only discover in first year that they do not have the innate skills needed to be a programmer. A supportive program structure will route these students into alternative programs where coding skills are not required, but that does not mean that 90% of all entrants should pass programming subjects.

Another way in which Universities exert pressure is in connection with student subject evaluations. At the University of Melbourne, (the infamous) question two asks whether "this subject was well taught", and staff who are unable to consistently maintain average scores greater

than "neutral" are hindered in their search for promotion, and the Department itself faces financial penalties. This sometimes means that staff are reluctant to initiate change, to experiment with innovative teaching techniques, or to teach challenging material. (It also raises the question as to the standard against which students are answering the question, but that is another issue. Again, it seems likely that responses to such questions are incomparable between disciplines.)

Government regulation and policy changes are a further significant factor. Our recurrent funding is government-derived, but typically is delivered to the university as a whole and thus the effect on a department of government funding changes is felt only indirectly. Other changes, however, may have a more direct impact. A recent example is that changes in Australia to visa requirements, visa conditions, and criteria for permanent residency make it much less attractive for international students to undertake an 18-month coursework masters program. If we see such programs vanishing over the next few years, the inevitable conclusion would be that the curriculum depends more on parameters set by the Department of Immigration than on academic merit.

I. National and international accreditation bodies Another source of positive influences on course structures are the various program structures prepared by professional bodies such as the ACM (`http://www.acm.org/education/curricula.html`), and accreditation bodies such as the US ABET, the Accreditation Board for Engineering and Technology (`http://www.abet.org/`).

Various other bodies scrutinise degree programs, even in the absence of specific curriculum specifications, and in doing so serve as a force that guides curricula in certain directions. For example, in Australia both the Australian Computer Society (ACS) and the Institution of Engineers (IEAUST) accredit undergraduate degree programs in our discipline, and accreditation is usually considered a marketing necessity.

Our experience is that colleagues use these recommended curricula such as the ACM/IEEE Computing Curricula 2001 (Joint ACM/IEEE Task Force on Computing Curricula 2001) to defend their opinions when the change they are advocating and the recommendation happen to coincide; at other times, the relevance of the curriculum is not even mentioned.

J. Academic fashion The enrolment marketplace is competitive. We want our programs to be attractive to students, and for the best students to choose our institution. In principle, we would like our programs to be chosen on reputation: academically strongest, most up-to-date, greatest industry relevance, best teaching, or whatever particular feature we believe describes our particular approach to tertiary education. In practice, we all know that students also consider a great many other factors: how easy subjects are to pass, flexibility in delivery, hours required on campus, articulation paths, availability of car parking, and so on. If we suspect that students choose a competitor because, say, they offer a program on web technology, we may be tempted to do the same.

Ultimately, increasing student numbers means taking the applicants that other institutions reject – and making corresponding reductions in the difficulty of the subject material. Some "masters" programs on offer in Australia are little different from the undergraduate programs at the same institutions, and thus fill a market niche at a cost to academic credibility.

Other kinds of academic fashion are also an influence. In the 1980s, Pascal was the most widely-taught first programming language – not because it was significant in industry (it wasn't), but because it was perceived as a good way of teaching the nuts and bolts of coding. Today, many argue that teaching the principles of object-oriented programming should come before basic coding skills.

In every ambitious decision there is the risk that it will be regarded as being "brave", and in any innovative program there is the possibility that it will be seen as non-mainstream. So we sometimes consider whether or not proposed changes fly in the face of the conventional wisdom, as expressed by the programs of study offered by the institutions with which we compete for students. This pressure also sometimes works the other way, and an innovation that appears to be successful is sometimes quickly mimicked elsewhere, even when the same input factors may not be present. One only has to think of the many IT Masters by Coursework programs at Australian tertiary institutions, and the many e-Commerce and web-oriented programs that erupted during the IT boom of the late 1990s.

5 Survey instrument

To measure the extent to which these various factors – and possible other factors that we had not considered – we prepared a survey, and solicited responses from a wide range of people in computing departments and schools across Australasia. Almost one hundred senior staff in a total of 31 institutions were sent individual email requests by one of the four authors, explaining the motivation for the questionnaire and inviting them to respond. A window of one week was allowed, with a follow-up email sent another week after the deadline if no response had been received. We received completed surveys from 31 individuals from 19 institutions, covering 75 incidents of curriculum change. The largest number of respondents from a single institution was 3.

After explaining how we wished their responses to be sent (by editing the email and sending it back), the ten factors listed in Figure 2 were given. Respondents were asked to consider two incidents of proposed curriculum change according to the list given in Figure 1, and indicate the extend to which each of the ten factors had driven or inhibited change on a seven-point Likert scale, with -3 representing "strongly inhibited", and $+3$ indicating "strongly drove".

Our key hypothesis was that the two most "desirable" of the factors, namely academic merit and professional curricula, would be relatively unimportant factors, and that other more pragmatic concerns would dominate.

Figure 3 lists the core part of the instructions. Where possible, we arranged for a person known to the recipient to be the one of us that sent that request, hoping this would increase the response rate. The survey instrument had two parts. One sought numeric scores for the importance of each of the ten potential drivers or inhibitors of change. The other invited respondents to make free-form comments about the change, how it was made, and whether it had been implemented.

With the respondents' comments at hand, we undertook a three-stage cyclical approach to qualitative data analysis (Miles & Huberman 1994). Our goal at this stage of data analysis was to gain a better understanding of the ten proposed factors (see Figure 2) we thought might influence curriculum change. First, we categorised each comment under what we thought was the most appropriate

For two of the five types of curriculum change listed below [or all five types, if you have the time]:

- First, consider an instance of that type of change that was proposed for your Department during the last 10 years.
- Second, estimate the extent to which the factors (a)-(j) shown below influenced the decision in your Department to proceed with the proposed change.

To answer, replicate the complete set of questions below from the "start" line to the "end" line for each episode that you wish to provide feedback on. For each question, edit the line of numbers to indicate your desired answer with XX. For example, the line

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-3  -2  XX   0  +1  +2  +3
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represents a factor that had a slight inhibiting effect on your Department's consideration of the proposal. The line

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-3  -2  -1   0  +1  +2  XX
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represents a factor that was a key driver of the change.

Figure 3: *Instructions given in the survey sent to colleagues.*

heading. Secondly, we eliminated those factors that received little attention. Finally we discussed the remaining comments in light of the four factors that stood out most: influential individuals, financial pressures, pedagogical argument, and academic fashion.

While the total number of responses was 75, the results for the individual categories are based on small numbers of responses. Hence we think of our results as merely pointing to certain conclusions, rather than providing definitive evidence.

6 Results

The influence of each factor on curriculum change is shown in Figure 4, by each of the five categories of change and, in the bottom-right corner, overall.

In this figure, the dark bars are the average influence of each factor, and the light bars are a vertical histogram illustrating the proportion of responses with each value in the range -3 to $+3$.

Some observations are immediately striking. One is that, for all categories, the dominant factor is "influential or outspoken individuals". Change is driven, or blocked, by people who strongly voice an opinion. Student viewpoints was the second-most dominant factor, supporting, arguably, the claim that our institutions have been successful in becoming student-centred.

Another striking issue is that professional curricula have been of little relevance. We had anticipated this result, as it fits with our own experience. More surprisingly, university or government requirement was of little relevance also. Arguably this was because our instrument separated university requirement from financial pressure; if we had more loosely termed category (h) as "university or government pressure" the outcome may have been rather different. However, we note that financial pressure did not appear to be an important factor – another surprise.

Issues such as academic fashion were seen as important factors for major changes such as introduction of a program (categories 1 and 2), whereas academic merit was relatively unimportant. The only level at which academic merit was significant was for changes within a subject – also the only level at which student ability was a major factor (but note that we only had four responses in this category). Overall, therefore, it is difficult to escape the conclusion that academic merit and principle are of little importance as drivers of our curricula. And the larger the changes, the smaller their role.

In line with our statistical results, the influence of key individuals was again highlighted in respondents' comments. One academic wrote, for example, that "the only thing that results in curriculum change is a massive effort by one or two people, who need to develop a proposal and course material, argue the case in front of the School or Department, and then go ahead and implement the change." It is understood then that influence can arise from dedicated work at several stages as much as following the directives of those in superior academic positions.

We grouped a variety of comments under the category of financial pressures. Several academics wrote that the University saw their departments as "cash cows" for the organization as a whole. Because of this, they had to produce a "financial winner" so much so that they were driven to retain students for the reason that "an extra year would increase income by at least a third." Decreasing enrolments forced one department to recruit students from "previously-untapped sources." Although financial pressures were largely seen to be negative, one academic wrote that the additional funds generated with a curriculum change "allowed us to generate revenue for research and other activities."

Comments regarding pedagogical arguments were not based in a solid educational position. Rather, they seem to reflect a frustration that possible options were not fully investigated. As a result, decisions tended to be based on emotional or political arguments. One telling comment summarises this sentiment: "Inhibited, for a time, by the problem of choosing a replacement for Pascal. The first decision – drop Pascal – was relatively easy compared to agreeing on its replacement!"

Academic fashion appears to be shaped both from a need to compete with other institutions and from a need to please incoming staff. One academic, for example, wrote that a particular curriculum change was driven by "newer less experienced staff [who] pushed through some populist ideas at the expense of academic rigour." Although not a particularly sound basis for curriculum change, internal social trends appear to markedly influence decisions.

Finally, participants were asked whether the curriculum changes they had considered had been made, and whether they had achieved their objectives. Overwhelmingly, the answer to both questions was yes.

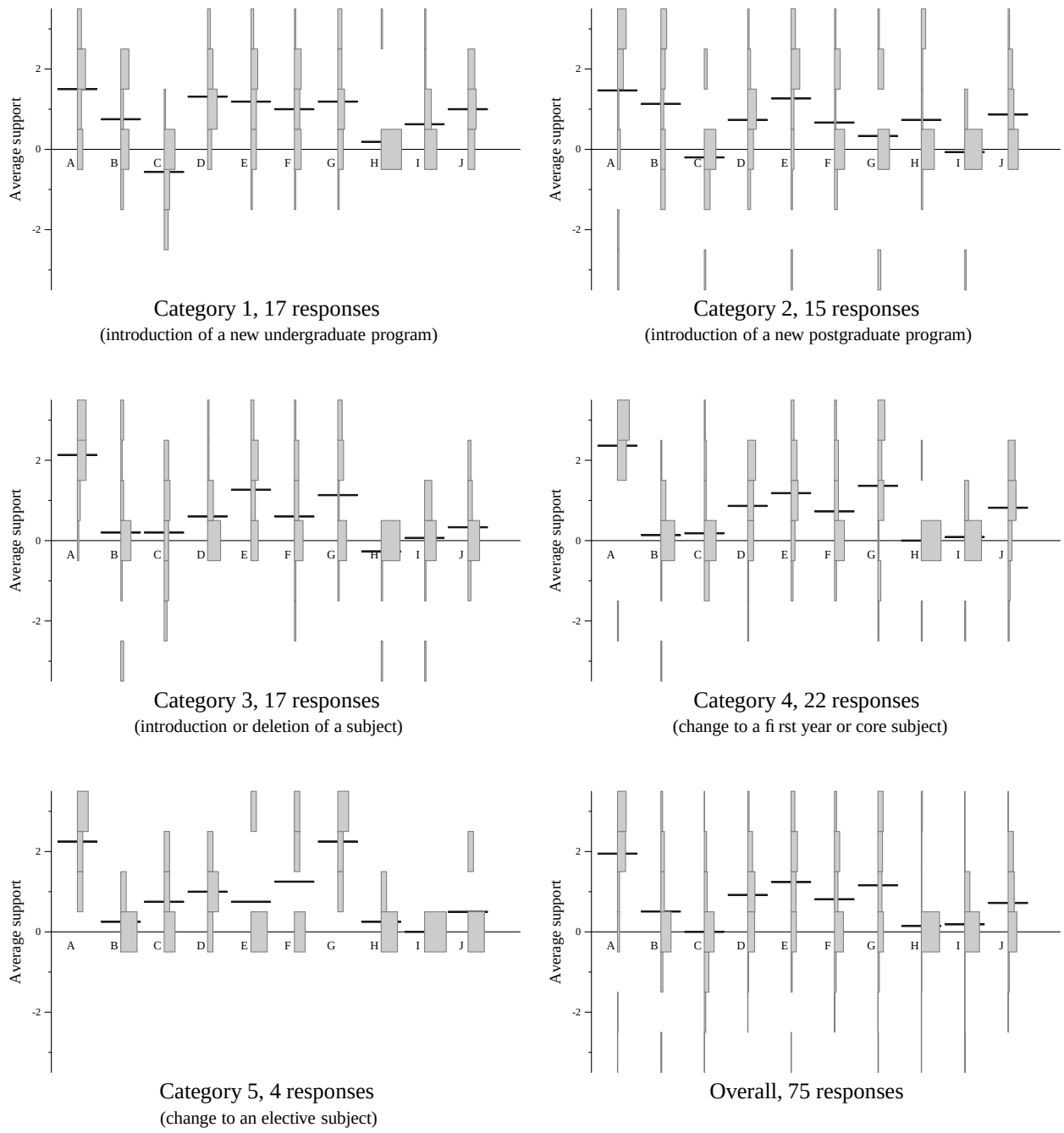
7 Discussion

Henkel & Kogan (1999) note that many issues are common in curriculum debates, irrespective of discipline, for example:

- maintenance of academic standards;
- balance between academic and vocational objectives;
- transferable skills development; and
- effective use of resources.

They observe that curriculum change is predominantly incremental.

Jones (2002) lists five conditions that promote and sustain changes in the curriculum:



Category 1, 17 responses
(introduction of a new undergraduate program)

Category 2, 15 responses
(introduction of a new postgraduate program)

Category 3, 17 responses
(introduction or deletion of a subject)

Category 4, 22 responses
(change to a first year or core subject)

Category 5, 4 responses
(change to an elective subject)

Overall, 75 responses

Figure 4: *For each category of curriculum change, the impact of each factor. The solid horizontal bar is the average contribution of the factor. The lighter grey area is the percentage contribution made by each value in the range -3 to $+3$. (These areas form a vertical histogram.) For example, in category 3 the usual value chosen for factor H is 0, whereas the dominant value for factor A is $+3$.*

Legend. *A: influential individuals. B: financial pressure. C: staffing. D: industry viewpoints. E: student viewpoints. F: student capabilities. G: academic merit. H: university or government requirements. I: professional body requirements. J: academic fashion.*

- mutual trust amongst stake-holders;
- committed and consistent leadership;
- proceeding with a non-threatening, incremental pace of change;
- professional development for academic staff; and
- the use of purposeful incentives.

Ironically, with the focus of much departmental management on matters of finance, property and external relations over the last decade, the curriculum has been largely overlooked (Bocock 1994). The curriculum needs to be managed differently. There needs to be a balance between institutional objectives and that of academic staff.

In the present study we have identified possible factors in curriculum change in our discipline. Our results point to the tentative conclusion that changes are driven by individuals, politics, and fashion more than they are driven by academic merit and external curricula. At the same time, there appears to be considerable confidence that the right changes are being made. In the midst of widespread difficulties in the higher education system, academics appear to continue to implement change and develop the curriculum while remaining confident that of having control over what is taught as computer science.

Our results are preliminary – the number of respondents to our survey has been too low to allow any claim of statistical significance. We have aimed to make the survey easy to complete, with the hope of increasing the number of responses. However, this has also led to compromises in the study design. As noted by one of the respondents, the design "seems to assume that each factor is on one side of the debate", whereas, for example, issues for and against a change may both be based on student viewpoints. It would be desirable to undertake a study of this kind in greater detail, coupled for example with an examination of academics' overall perceptions of the quality of their programs.

We have found the literature on curriculum change with a focus on our discipline very limited. As pointed out by a referee, deeper insight into the curricular change process can really only be had from detailed case studies, by trying to "trace the complex interactions between the factors" of change, rather than simply providing, as we do, relative weightings. Besides, the proposed factors may well reflect the authors' bias, and a deeper analysis based on more detailed data about actual curricular changes might well suggest a better categorisation. There is considerable scope for more work in this area.

We have not attempted to compare responses from different types of universities. Becher & Barnett (1999) report that, in the UK, the older and more prestigious universities are the slowest to adopt new approaches. They suggest that "those who stand most to benefit from some special differentiating feature are the most likely to be open to experimentation" and so "it is among post-war universities and polytechnics that innovations such as cooperative teaching programmes with industry, learning contracts, independent learning and problem-based enquiry are most commonly to be found." It would be interesting to investigate whether curricular changes, and especially changes to instructional methods, are uniform across different types of universities in Australasia.

Acknowledgements

We thank the many colleagues who were part of the survey and the referees for helpful comments.

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