Improving the Chances of Getting your IT Curriculum Innovation Successfully Adopted by the Application of an Ecological Approach to Innovation

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Abstract

University curricula in Information Technology (IT) necessarily require frequent change, updating and even complete revision due to advances in technologies, new methodologies, and changes in how people and organisations make use of computers. We argue that curriculum change, which is a complex process that involves many actors, should be seen through the lens of innovation theory and studied as an innovation. To understand curriculum innovation it is useful to examine how interactions between both human and non-human entities contribute to the final curriculum product, and this paper discusses theories of innovation and proposes an ecological approach to the building and re-building of university curriculum in IT. Ecology is concerned with interrelationships: between different living things, and between living things and their environment. Building on our previous work in this area, in the paper we explain the ecological approach by its application to several specific case studies in IT curriculum innovation. We use this ecological approach in an attempt at explaining why some elements of IT curriculum innovation are adopted successfully whilst others are not. Interesting as this might be from a theoretical academic perspective however, an explanatory theory is much more relevant if it can also be used practically. While we make no claim to being able to predict the success or failure of an IT curriculum innovation, we do suggest that this approach can be used to *improve its chances of success*. We argue that by making use of an ecological approach it is possible to improve the chances that a particular curriculum innovation will be adopted and used successfully.

Keywords: IT curriculum innovation, IS curriculum innovation theories, technology adoption, socio-technical factors, ecosystems, ecological model, environmental interactions diagram.

Introduction

Just because you believe that the information technology (IT) curriculum innovation you are proposing would be of benefit to the students, would be valued by their potential employers and would greatly improve the learning process is no guarantee that others will see it this way or that it will be successful. For any of these benefits to occur the curriculum innovation *first* needs to be accepted and adopted, and there are many cases in which this has not occurred.

Innovation diffusion theory (Rogers, 1995) suggests that the acceptance and use of a new product or process is due mostly to the characteristics of this product or process. It has been used to describe things like the “diffusion of hybrid corn in Iowa” and “black music in white America” (Rogers, 1995). The prime concern of diffusion studies is identification of factors that affect the speed with which an innovation is adopted, or that cause it not to be adopted at all. Davis (1989a, 1989b) has applied similar explanations to adoption of IT in organisations. Ecology, on the other hand, attempts to offer explanations relating to interactions and adaptations to change. In 1859 a small number of rabbits were released into the Australian environment by a farmer, homesick for his native England. The rabbits quickly adapted to their new environment and their numbers increased rapidly until they reached pest status. Ecology has been used to explain why this occurred and the high degree of ‘successful adoption’. In this paper we will show how an ecological approach leads to a richer understanding of the process of innovation, and how its application enhances the chance that an IT curriculum innovation will be adopted and used.

Models of Curriculum Development

Curriculum change can be modelled in many different ways and we will here consider just a few of those we consider most relevant. In the context of higher education curriculum Nordvall (1982), building on the work of Havelock (1969, 1971), identifies several models for curriculum change that he suggests all have relevance at the subject, course, and institutional levels: research, development and dissemination models; problem solving models; social interaction models; political and conflict models; and diffusion, linkage or adaptive development models (Tatnall, 2000). Models of change based upon a process of Research, Development and Dissemination are probably the most common way of attempting an explanation of the process of university curriculum development (Nordvall, 1982). In models like this, relying on logical and rational decisions, curriculum change depends on the use of convincing arguments based on programs of research. A rational and orderly transition is then posited from research to development to dissemination to adoption (Kaplan. 1991).

Research → Development → Production → Dissemination → Adoption

Figure 1: Research, development and dissemination models

Models like this could be considered as ‘manufacturing models’ as they follow a fairly logical and straightforward mechanical approach with one thing leading directly to another. They do not allow for or consider other influences, such as those due to human interactions. If we were to accept a manufacturing model like this as describing IT curriculum innovation then we might expect some of the following curriculum outcomes to be apparent across the world:

- A single programming language, the one most supported by research, would be implemented in all courses requiring programming.
- Programs of study with similar outcomes would be identical everywhere.
- The classroom delivery of all material would be moving towards the researched ideal and hence all delivery methods would be working towards this ideal.
- A graph could be produced showing the dissemination of ideas from centres of research throughout the world. The dispersion would depend only upon standard factors and could be predicted from previous dispersals of knowledge from such knowledge centres.

A fairly simple experiment can disprove these predictions. In countries not bound by centralised curricula the programs of study show wide variety, using many different programming languages and a wide variety of techniques for delivery. Some innovations seem to be accepted world wide, but many are adopted only locally. In this paper we will provide an alternative to this manufacturing model that better explains how IT curriculum is *really* developed.

IT Curriculum and Theories of Innovation

Innovation involves getting new ideas accepted and new technologies adopted and used. The introduction of new technologies, methodologies or content into a university IT course can thus be considered as an example of innovation. Our research has shown (Tatnall, 2002; Tatnall & Davey, 2002a, 2002b, 2003) that rather than being due to any supposedly objective characteristics of the technology itself (Rogers, 1995), the acceptance of an innovation is more greatly affected by the complexity of the interactions:

- between the people involved,
- between these people and the technology,
- between different technologies, and
- within the organisation concerned.

We will argue that if you want to understand *how* IT curriculum is built and re-built, and why one curriculum innovation succeeds where another has failed, then you need to examine how interactions between both human and non-human entities contribute to the final product. To do this it is necessary to use approaches that allow the complexity to be traced and not diminished by categorisations (Law, 1999) or assumptions about intrinsic attributes of humans and non-humans. One way that this can be achieved is by using models and metaphors that relate to how people interact with each other, with the environment, and with non-human artefacts. To accommodate these complexities and to provide a useful socio-technical perspective, an ecological model (Tatnall & Davey, 2002b, 2003) dealing with the interactions of human and non-human actors within the 'ecosystem' of the organisation provides a useful approach that not only gives insights into the innovation process, but also assists in getting innovations adopted. At the very least we need a set of words that enable us to discuss complex interactions rather than language that leads to over-simplification. This paper considers such an approach.

The theory of innovation diffusion (Rogers, 1995) suggests that there are four main elements to adoption: characteristic of the innovation itself, the nature of the communication channels, the passage of time, and the social system through which the innovation diffuses. Rogers argues that the attributes and characteristics of the innovation itself are particularly important in determining the manner of its diffusion and the rate of its adoption, and outlines five characteristics of an innovation that affect its diffusion: relative advantage, compatibility, complexity, trialability, and observability. We have argued (Tatnall & Davey, 2002b), however, that this approach to innovation is rather too simplistic and that a better model would put more emphasis on interactions of the people and technologies involved.

Recent research has illustrated some of the complex processes people go through in deciding whether or not to adopt an educational technology (Naidu, Cunnington & Jasen, 2002; Tatnall & Davey, 2003). In this paper we will incorporate some of the concepts of innovation translation from actor-network theory (Callon, 1986, 1987, 1999; Latour, 1988, 1991, 1996; Law, 1991; Law & Callon, 1992) into an ecological framework in which we will consider how adoption of IT curriculum innovations might occur. Using a socio-technical approach such as this enables identification of factors that do not emerge from traditional approaches to innovation theory and allows us to improve the chances of successful curriculum innovation.

An Ecological Model of Innovation

Ecology is a relatively new science, being proposed in 1869 by Ernst Haeckel as "the total relations of the animal to both its organic and its inorganic environment" (Krebs, 2001, p. 2). The dictionary defines ecology as: "the branch of biology dealing with the relations of organisms to one another and to their physical surroundings" (Pearsall & Trumble, 1996, p. 446). Ecology is related to other biological studies as shown in Figure 2 below.

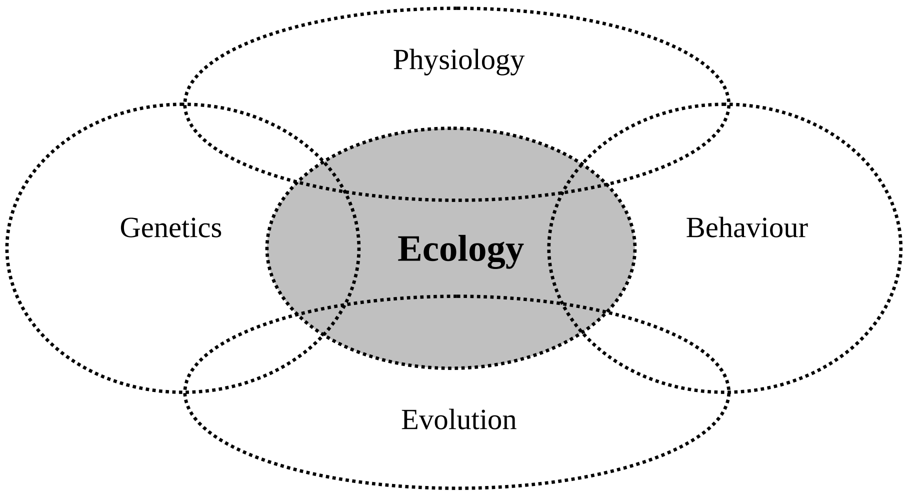

Figure 2: Ecology and other branches of biology (adapted from Krebs (2001, p. 2))

Ecology is concerned with interrelationships; between different living things, and between living things and their environment. More specifically, Krebs (2001, p. 2) defines ecology as "the scientific study of interactions that determine the distribution and abundance of organisms." It is thus concerned with the way that organisms respond to the various forces that operate within the environment.

Systems Theory has a wide range of applications (Lilienfeld, 1978) including both computing and biology. In this paper, however, we will concentrate on one specific type of system: an ecosystem. A classical definition of an ecosystem is "a natural unit of living and non-living parts that interact to produce a stable system in which the exchange of materials between the living and non-living parts follows a circular path" (Ville, 1962). Krebs (2001) sees an ecosystem as a biotic community along with its abiotic environment, and points out that some ecologists (Evans, 1956; Rowe, 1961) see the ecosystem is the basic unit of ecology. A dictionary definition of an ecosystem is "a biological community of interacting organisms and their physical environment" (Pearsall & Trumble, 1996, p. 446). These definitions also describe some of the essential characteristics of any human system and we should see if some of the concepts found in general ecosystems theory apply to human systems where an innovation is to be implemented.

Two key biological principles exemplify the concepts of ecology (Townsend, Harper & Begon 2000):

- Organisms behave in ways that optimise the balance between their energy expenditure and the satisfaction they obtain.
- Organisms operate within a competitive environment that ensures only the most efficient of them will survive.

Habitat, ecological niches, the exploitation of resources in predator-prey interactions, competition, and multi-species communities (Case, 2000; Krebs, 2001) are all important considerations in ecology. Many different individuals and species typically occupy any given ecosystem, and they can be considered to interact in many different ways. An ecosystem is a highly complex entity due to the large number of living things inhabiting it, and to the variety of interactions possible between each of these (Tatnall & Davey, 2002a).

These concepts can be immediately applied to the introduction of an IT curriculum, and when examining the potential for an IT curriculum innovation to succeed it can be useful to examine the co-operative and competitive educational environment in which this will exist, the effort required in its implementation, and the satisfaction likely to accrue to its developers from its use. The 'ecosystem' represented by an innovation in the IT curriculum would contain, at least, the following human 'species': lecturers, researchers, university administrators, professional computing bodies, textbooks writers/publishers, students, representatives of the computer industry and Course Advisory Board members. It also contains many inanimate objects (non-human species) relevant to the formation or change of the curriculum, including: computer laboratories, software, programming languages, analysis and design methodologies, textbooks, programming manuals, lecture theatres, discussion rooms, computer networks, and so on. The 'environment' thus consists of all these species living within the university.

We are not, of course, suggesting that IT curriculum is in any way a biological entity, and we must digress here to issue a word of caution on the limitations and appropriate uses of models and metaphors. A model is not itself reality, but just a representation intended to fulfil some explanatory purpose; models thus always have limitations. The dictionary describes a metaphor as a term "applied to something to which it is not literally applicable, in order to suggest a resemblance" (Macquarie Library, 1981, p. 1096). Metaphors are useful only in viewing certain aspects of a complex system, but can greatly improve understanding of complex issues. James Lovelock, devisor of the Gaia hypothesis, once remarked. "You've got to use metaphor to explain science, it's part of the process of giving people a feel for the subject" (Bond, 2000). It is our contention that the current mental models of the innovation process are deficient in that they ignore the basic complexity of any situation in which the innovation might 'take root'. By viewing the innovation as a new organism in an old environment we can attempt an analysis of the situation that might lead to more successful implementations or more useful choices between possible innovations.

When using an ecological metaphor, curriculum development can be seen as attempting to introduce change within an environment. The problem of course, is the large number of interested parties that must be contended with before this change can be implemented, and how they might co-operate or compete. The introduction of any new IT curriculum or curriculum element requires expenditure of energy in costs, time, and training. The ecological model suggests that if faculty members find that the use of this curriculum element requires the expenditure of too much energy, they will not use it. To determine what is 'too much' we should look at the satisfaction they obtain from this expenditure.

In an ecosystem many different individuals and species typically occupy a similar space and can be considered to interact in the following ways, some of which when applied to humans might be considered under the heading 'politics':

- **Competition**. In biology this occurs when two individuals or species each strive for the same thing, which is typically food, space or some other physical need. Competition in nature can occur both within and between species. IT curriculum development contains many examples of competition. Sometimes competition can be seen between two IT lecturers with different philosophies or approaches to the teaching of a particular topic area. This can lead to various problems including time-wasting clashes of personality between academics, or subject material being taught twice. Software products such as Linux and Windows, Excel and Lotus 123, or Visual Basic and Java compete for a place in the curriculum. Competition may also be perceived in the form of scarce resources being use up by a competitive technology, or in determining the 'fittest' topics and techniques best suited for survival (Darwin, 1859) in the curriculum.

- **Co-operation.** When one population is benefited by the presence of another, but can survive in its absence we have a co-operative situation. There are several variants on co-operation in ecology depending on whether each entity benefits or whether there is a degree of harm to one entity involved. In an IT degree course some subjects rely on earlier subjects (i.e. they have prerequisites) and this can be seen as a form of co-operation in which each subject benefits from the existence of the other (mutualism). Technology can also co-operate with the physical environment. An example is in software and programming languages where, for instance, the use of Visual Basic in a computer laboratory requires the presence (and co-operation) of Microsoft Windows. Likewise subject material that relies on the use of a specific textbook could also be seen as an example of co-operation.
- **Filling a niche**, often by occupying an unfavourable location, is a technique used by some species to avoid competition. An IT curriculum innovation that fills a specific but limited need may become established in a niche and survive through co-operation as a skill set develops in the technology. We will later see an example of this in the teaching of Pick. When considering the introduction of a new IT curriculum element we can look to see if a boundary exists around the situation intended for it that will create a niche.

In IT curriculum development we should thus look at all the factors involved, both human and artefact, to see which could be expected to compete, and which to co-operate (Lewin, 1947) to become part of the surviving outcome. A non-human stakeholder (Callon, 1987; Latour, 1988), such as a development tool or methodology, must co-operate with the environment, compete successfully, or die out. This may mean a new curriculum element becomes incompatible with an old element and, so, replaces it. Alternatively it may mean that two new design tools can be used together, or that a particular curriculum element is compatible, or perhaps incompatible, with the desires and interests of a particular faculty member.

Ecological metaphors have also been useful in areas other than biology and curriculum change. The type of ecological framework we have discussed has also been used quite successfully in several other areas including treatment of poor health (Grzywacz & Fuqua, 2000), studies of organisational behaviour (Barnett, Mischke & Ocasio, 2000), world politics (Simon, 1998) and a study of the effects of violence on children (Mohr & Tulman, 2000). Ecology, as a framework, tells us to expect progress of a task through co-operative or competitive behaviours of the animate and inanimate factors in the environment. A factor that cannot compete or co-operate is inevitably discarded.

Application of the Ecological Model to IT Curriculum Innovation

This theoretical framework may have some intellectual appeal but should be tested to see if it leads to useful analysis. The research reported in this paper consisted of several case studies involving curriculum innovation. In each case study the intent was to investigate whether any of the following ecological factors has any relevance:

- The environment in which the IT curriculum innovation occurs.
- The energy expenditure in implementing and using the new curriculum innovation.
- Sources of competition for this curriculum innovation.
- Likely co-operative curriculum entities and technologies.
- Whether the curriculum innovation can find a suitable niche in which to thrive, free from competition.

Each of the following case study examples is real, the data having been collected by the authors. In each case however, for privacy reasons we have concealed the identity of the educational institutions and people involved. Two of the case studies are of the introduction of new software technologies into the university curriculum while the other relates to introduction of a new high school subject. Although this paper refers primarily to university curriculum we have included this third case study to illustrate that these processes have some value at other levels of education.

Introducing Visual Basic into the IT Curriculum of an Australian University

This case study (Tatnall, 2000; Tatnall & Davey, 2001) is set in an Australian capital city in the mid-1990s when two former Colleges of Advanced Education (CAE) were in the process of merging to form a new university which, to preserve a degree of confidentiality, we will call Bourke University. Using an ecological approach (Tatnall & Davey, 2002a, 2003) to curriculum change we will consider the ecosystem to include: IT academic staff and students, degree courses, laboratory hardware and equipment, laboratory software and the Course Advisory Committee (consisting of industry representatives) operating within the environment of the new university. The on-going tussles for curriculum change are considered in the light of co-operation and competition between various entities in the ecosystem. Also to be considered is the possibility and value of filling niches by some aspects of the curriculum and the energy expenditure necessary in implementing the change.

Before Visual Basic (VB) was introduced at one of the CAEs just prior to the merger, the programming languages taught were COBOL, the dBase III+ programming language, Pick Basic, and a pseudo-assembly language programming system called Alice, developed by one of the academic staff (James). Each of the merging institutions saw its prime teaching role as producing IT professionals who would well fill the needs of the local computer industry. Consequently the new university felt a need to teach with only ‘real’ programming languages, software tools and systems development methodologies. The students saw their courses as leading to jobs in the computer industry. This was the environment into which VB needed to emerge and to evolve as an appropriate teaching language.

During the merger a new Information Systems degree needed to be developed and Visual Basic was suggested as an important teaching language in several subjects. VBs main allies were the IT academics Fred and Paul. To be adopted as the main programming language taught to first year students however, VB had to compete with Pick Basic which had been taught successfully for several years at the larger CAE before the merger. The Pick operating system had been adopted at this CAE in the mid-1980s after one of its academic staff, Stephen, had encountered it when working on a consulting job. As Pick was not at that time used by any other local tertiary teaching institution Stephen was easily able to convince his colleagues that if their students studied Pick (and its programming language Pick Basic) the institution would be able to successfully fill a niche for supplying Pick Basic programmers to those companies with Pick installations. A major problem faced by Fred, Paul and those other academics wanting to get VB accepted into the new degree course was that as Visual Basic was used in several other universities there was no possibility for students filling a niche market as there was with Pick. Pick Basic was thus a definite and strong competitor that would oppose the introduction of Visual Basic as the first programming language in the degree. A view of the interactions, at this point, can be seen in the Environmental Interactions Diagram (EID) shown in Figure 3.

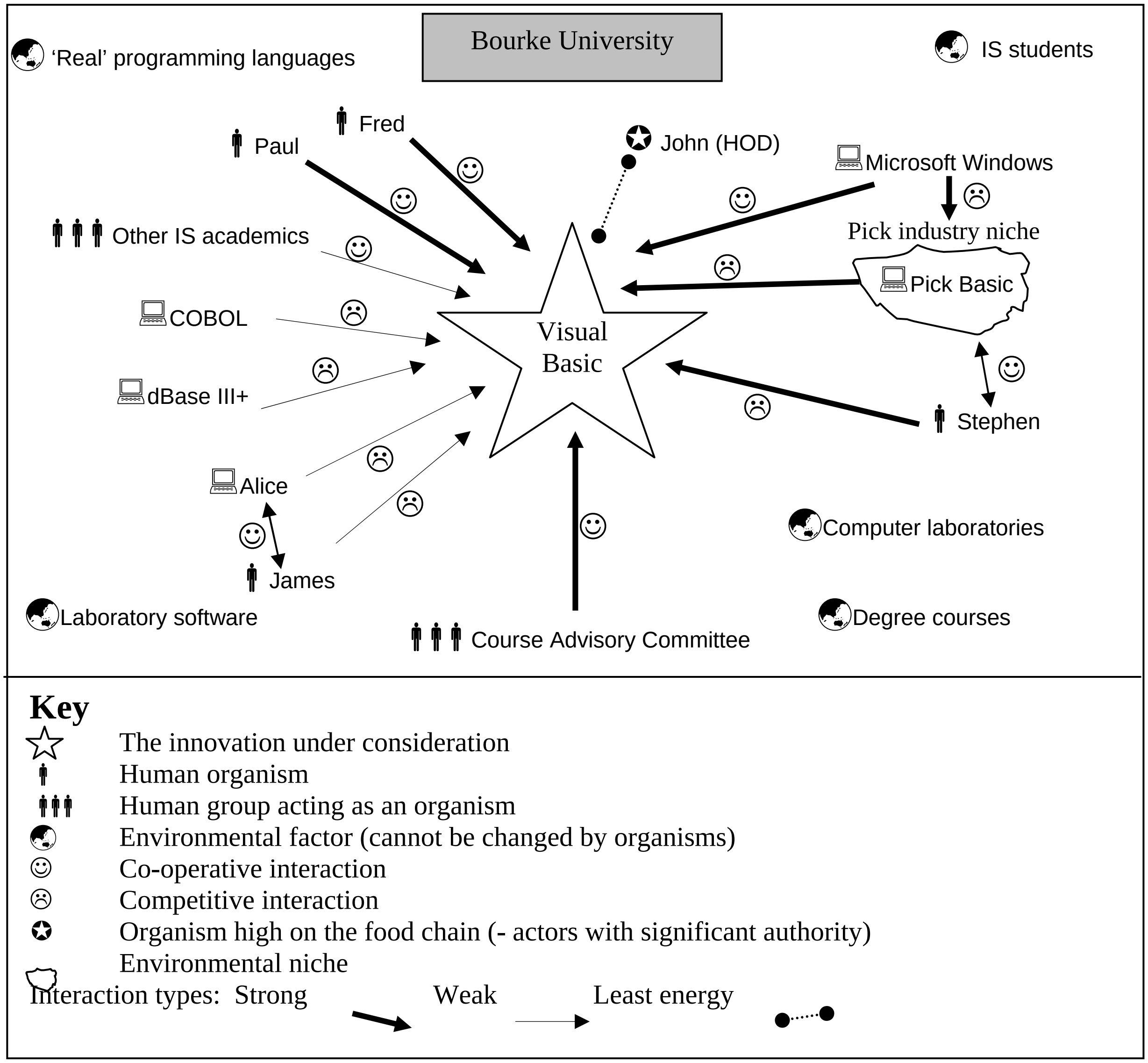

Figure 3: Bourke University Environmental Interactions Diagram

Surprisingly the COBOL and dBase III+ programming languages offered little competition to the introduction of Visual Basic, probably because they had no academic allies to assist them and to promote their cause (Latour, 1996). Another potential competitor however, was Alice – the assembly language programming system. When Alice had been developed in the 1980s there had been little question that Information Systems students should be taught something of the internal workings of a computer and of assembly language programming. This was the nature of the environment of the time. By the mid-1990s, however, there had been a change in the climate that caused considerable change to the computing environment. The evolution of computer technology from mainframes and minis to PCs running Windows meant that the need for Information Systems students, as distinct from students of Computer Science, to have a good understanding of the internal workings of a computer was much reduced. This change marginalised the importance of assembly language programming and made it easier for Visual Basic to compete with Alice. VB quickly moved to occupy Alice's place in the environment, resulting in the rapid decline to extinction of Alice.

Another test required of any new programming language before it could be accepted into the Bourke University curriculum was whether it could be seen as a 'real programming language'. This was determined by whether it was commonly used by the computer industry and would find a ready place in this larger environment. In this, at least, Visual Basic had no problems and was readily seen as suitable in this role. Pick was also seen as real – it was certainly in use in segments of the industry, but Alice was not. In the 1980s, however, Alice was seen as teaching a 'real skill' – programming in assembly language, and so was accepted. With the climatic changes of the 1990s its status as a real language also changed.

Visual Basic had good co-operation from Fred and Paul and many of the academic staff who were becoming increasingly frustrated with using Pick Basic and who saw no future role for Alice. It also received considerable support from members of the industry-based Course Advisory Committee who saw an important role for VB programming in their companies.

After all this interaction and contention the resulting new degree course retained Pick Basic as the first programming language – it was still a strong competitive entity in the environment, but gave Visual Basic a place in a second year core programming subject and an elective teaching graphic user-interface design techniques. Alice disappeared entirely from the curriculum. A major advantage seen in keeping Pick in the curriculum was that this involved less energy expenditure than replacing it would have. Replacement would have involved placating Stephen – a strong advocate for Pick, and the production of copious new teaching materials.

Choosing Between Two Object Technologies in the Undergraduate Curriculum

The second case study is of the introduction of one of the object-oriented technologies into an undergraduate degree in 2003 at Wills University. The non-human organisms in this case include existing structured methodologies and technologies such as structured analysis and design, and structured programming languages such as COBOL. New contenders with some support amongst the humans included mainly an IBM version of Smalltalk and surrounding object-oriented methods in direct opposition to the Java tool set available from Sun Microsystems.

As with most universities, interaction was in an environment including a set program structure allowing a possibility of changing the content of up to four subjects, approval processes requiring input from a Course Advisory panel, and effectively almost no money being spent apart from the sunk costs of existing laboratories and operating platforms.

In retrospect it can be seen from study of the minutes of meetings and discussion papers that a small group of human 'organisms' played significant parts in the ecosystem during the introduction of the technology. These humans included Luke – the academic with ultimate responsibility for signing off any change, Adam and Charles – the existing academics in charge of target subjects, and Mark – the co-ordinator of teaching into the degree.

The issue of changing technology had been raised several times over a number years and the University was clearly several years behind in making decisions on this technology. During this period both the person in ultimate control (Luke) and the controller of the degree (Mark) had been co-operating to minimise energy expenditure. In these years the output of the degree was constant and a zero input for some output can be seen as very efficient. This co-operation between organisms with wide responsibilities can be seen as a powerful explanation of conservative behaviour in organisations, but such a view overlooks the amount of energy required to overcome the desire of other organisms to make change. In this case a predator arrived in the environment in the form of a visiting professor, Glen. This professor had been funded by the Department to come to Australia to contribute to their research efforts.

As an 'outsider' the professor could be expected to have little impact as many factors existed in the environment strongly promoting the technology and these had resulted in no change.

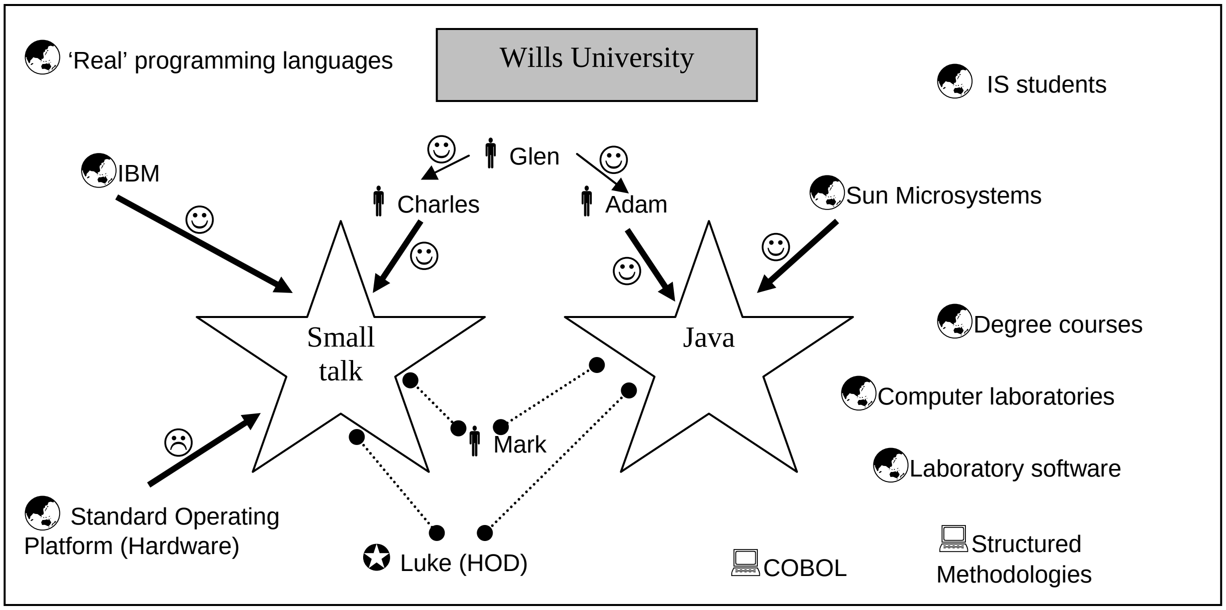

Figure 4: Wills University Environmental Interactions Diagram

The effect of Glen, however, was marked. Charles used the forums provided by the professor to mount a campaign for change. This co-operation between predators was aimed at the grazing organisms in that Glen was motivated to have *some* effect occur as a result of his funded trip, and Charles could clearly establish a reputation by being associated with such a change. At this stage the exact nature of the technology could be seen as irrelevant as almost none of the relevant decision makers had any knowledge of the technology. As pressure mounted to make change the two other main organisms (Charles and Adam) arose as interacting entities. Whereas Charles was championing the IBM Smalltalk technology, Adam had been researching Java technologies. In each case the co-operation between the technology and the human stemmed from invested time in gaining knowledge of the technology. Charles encountered a significant problem however, as the university's standard hardware operating platform did not contain sufficient memory to run Smalltalk satisfactorily.

Eventually the decision makers were spending so much energy in containing the move to new technologies that a decision was forced upon them. At this stage a coalition of predators achieved dominance in the environment as shown in the EID in Figure 4. Luke and Mark aligned with Adam, and Professor Glen returned home. Faced with this array of predators Charles was forced to retreat and the Java technology achieved dominance.

The Introduction of a Computer Awareness Subject in a High School

In the late 1970s computers were just starting to appear in Australian high schools. Most common was the Apple // but several others types were also present, including some mini-computers. While many educators saw the use of computers in schools as a good thing that would offer possibilities for considerable educational improvement, few then claimed to fully understand how to use them to best advantage. One of the first curriculum ideas to emerge was the concept of 'Computer Awareness'. The idea was to introduce high school students (and also those teachers who knew little of computers) to ideas of how a computer worked, how computers might be used in organisations, and some of the social implications of this use. The situation in the typical Australian high school of the late 1970s and early 1980s now often included an Apple // computer and one or more enthusiastic teachers who were keen to make use of it. It also included many other teachers who were either apathetic to computer education, knew very little about it, or were actively against it.

This case study concerns the introduction in 1979 of a core Computer Awareness subject into the Year 10 curriculum at Grevillia High School in the suburbs of Melbourne. The school had recently acquired an Apple // computer with 16Kb RAM and a cassette tape drive as the result of a curriculum innovations grant submission to the Federal Government. The curriculum innovation came mainly from the initiative of one science teacher (Donald) at the school who was then also a member of the Victorian Education Department's Secondary Computer Education Committee. His idea, based on discussions with other members of this committee, was for the subject to consist of three parts:

- how a computer works, how it is programmed, and a little of the history of computer technology,
- business and commercial uses of information technology, and
- the social implications of increased use of computers,

each of one term's duration, delivered by a teacher who understood and could relate to this area. The first step then, before proposing this new subject to the rest of the school, was to find teachers for each component and to gain their co-operation as allies in convincing the remainder of the teaching staff of the need for this subject. Fortunately, due to the climate of excitement with the possibilities of computer technology that existed at the time, this was not difficult to do and a co-operative team consisting of the science teacher (Donald), a commerce teacher (Maynard) and a teacher of social science (Louise) set about outlining the requirements for the new subject. As curriculum then was school-based and a matter to be determined by a Curriculum Committee consisting of the whole teaching staff of the school, the next step was to convince the remainder of the teaching staff to vote for this change to the Year 10 curriculum.

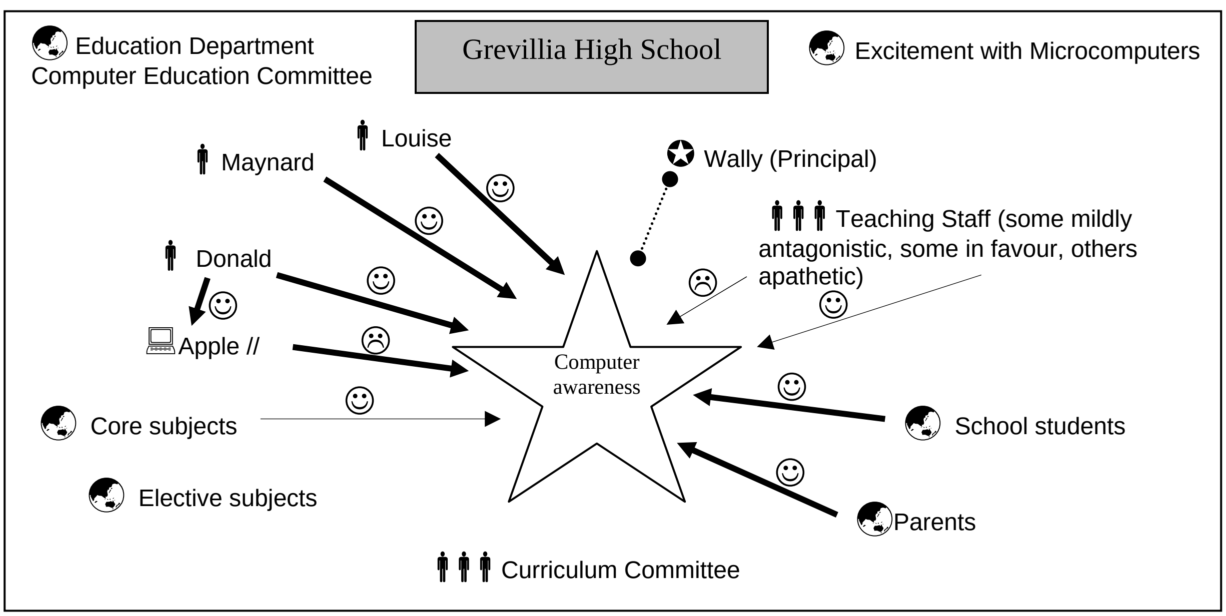

Figure 5: Grevillia High School Environmental Interactions Diagram

The Grevillia High School environment in 1979 (see EID in Figure 5) included about 750 students (150 students in Year 10), their parents, 60 teaching staff, core and elective subjects, the School Principal (Wally) and one Apple // computer. Most of the teaching staff had little knowledge of computers, but only a few were openly antagonistic to their use. Most of the students were intrigued by the new computer, and many of their parents saw the possibility of better jobs for their children if they learned how to use these new machines.

At that time in Year 10 at Grevillia High all students had to take four core subjects and choose six electives from a total of fifteen subjects. Donald, who was planning the new Computer Awareness subject, wanted this made into a *core subject*, but knew that it could not attempt to replace one of the other core subjects without a fight from the teacher of whatever subject it was attempting to replace. He decided to avoid this competition by instead proposing that the number of core subjects be changed from four to five, and the number of electives to be chosen subsequently reduced. This meant that as students could still choose from the same pool of electives, no particular elective was singled out to be replaced and so no teacher of electives saw a need to attack the proposal. Co-operation had been obtained and competition avoided.

The next obstacle was that Wally, the School Principal, was a believer in ‘good, solid academic subjects’ and saw Computer Education as a fad that would soon disappear. He was not in favour of the new Computer Awareness subject but appeared to decide that as a number of his teaching staff were very keen to introduce it, the energy he would need to expend to oppose its introduction would not be worthwhile, particularly as he was close to retirement. He did not compete but offered no active co-operation.

The curriculum innovation thus managed to find sufficient co-operation and to ward off the competition to the extent that it was successfully implemented. The new subject was first offered in 1980 and remained a part of the curriculum until changes in the computing environment by the early 1990s made it no longer necessary.

Getting these Innovations Accepted

In the first case study Visual Basic was adopted into the curriculum, but into a place subordinate to Pick Basic. If Fred had really wanted to undertake an implementation plan that might have succeeded in getting VB adopted as the principal programming language taught by his department, then using an ecological approach he might have proceeded as follows. He would have begun by looking for likely competitors. These would have included the programming languages Pick Basic, Alice, COBOL and dBase III+ and also colleagues like Stephen who were keen to keep Pick Basic in its current place. Next he would have looked for likely allies who might co-operate with him in promoting VB. Together with his co-operating allies he would then have looked for the ‘path of least resistance’ and tried to convince those of his colleagues then occupying neutral positions that it was in their interests in reducing energy expenditure to go along with him. A considerable difficulty he would have had to overcome would be to convince them that the niche then occupied by Pick Basic was unimportant or would soon disappear with likely changes in the environment. If he had been able to achieve these things then it is much more likely that VB would have been adopted as the main programming language in the undergraduate curriculum. This was, however, not what happened.

No one individual can be identified as the main element in seeking to introduce the object-oriented technologies into the degree course mentioned in the second case study. Let us suppose that Anne had been an academic in the department with a strong interest in OO who had desperately wanted to introduce Java into a significant place in the curriculum. Even if not involved in organising the arrival of the visiting professor she would have quickly seen him as an ally with whom she could co-operate. She would have then gone in a search for other allies, and any potential competitors. When it became clear that the main problem was one of energy expenditure – 'why change when all is going well?' she could have specifically addressed this by attempting to show how the change was inevitable and how inaction would just result in more energy expenditure at a later time.

At Grevillia High introduction of the new Computer Awareness subject was successfully achieved in all respects. The key here was in getting co-operation from the commerce and social science teachers, and in reducing potential competition from the teachers of other Year 10 subjects and the School Principal. Competition from the other Year 10 teachers disappeared when they could not identify any specific threat from the new subject – it did not directly threaten any one other subject, just reduced the number of electives to be taken. With the Principal it was a matter of energy expenditure – he was soon convinced that it would involve too much effort to oppose the new subject even though he did not entirely agree with its introduction.

The Ecological Model Compared with the Manufacturing Model

Issue	Explanation using a Manufacturing Metaphor	Explanation using an Ecological Metaphor	Advantages/reality
Stakeholders	Industry-informed formal discipline research. The decision is made by anyone able to count up the good and bad points.	All those who will be involved in the discussions. The decision is a consensus made by many people including those who will do the final delivery.	Our study shows the personal preferences (often arising from invested learning) often account for two different decisions in two institutions.
Selection of issues /selection of criteria	The only issues for change that arise come from new, published research. The original research also supplies the criteria for choosing between alternatives.	Issues are all those of interest to the stakeholders. Often stakeholders negotiate both issues to be considered and criteria to implement them in a way that favours their intended outcome. This is sometimes called 'the invention of need'. The negotiations involve either co-operation or competition between stakeholders (or sometimes both).	Some global concerns (object orientation or e-commerce becoming available) define issues. In most cases studied individuals had much say in how alternatives were to be compared. Often the legacy technology precluded some decisions being taken. In these cases the operating environment became a competitor for the new technology (eg Unix system unable to provide support for Microsoft products).
Application software for delivery of the curriculum	Use only that software with the best features.	Least energy expenditure could mean that software easily available to students is used. Alternatively it could relate to the software most easily obtained by the university.	Many examples can found where the lack of staff training, the cost of new servers or the incompatibility of operating systems with new software at least delays the introduction of a new curriculum initiative.

Figure 6: Application of the Ecological Model

Conclusion

In any field of study it is necessary to use language and metaphors in framing research questions and in offering explanations. In this paper we have shown how the discipline of ecology offers useful metaphors to accommodate complexity, and how the use of an ecological approach can provide useful insights into whether or not a curriculum innovation is likely to be adopted. This ecological approach involves looking in the educational environment for potential sources of competition, likely co-operative entities, the energy expenditure required to implement the curriculum innovation, and whether it might be able to find a suitable niche free from competition. Advantages of using an ecological approach to consider whether an IT curriculum innovation is likely to be successful are related to a presumption of complexity and interaction.

We have found, using a variety of case studies, that explanations of innovation implementation success can be aided by considering some, or all, of the following:

- The environment in which the IT curriculum innovation occurs.
- The energy expenditure in implementing and using the new curriculum innovation.
- Sources of competition for this curriculum innovation.
- Likely co-operative curriculum entities and technologies.
- Whether the curriculum innovation can find a suitable niche in which to thrive, free from competition.

Clearly it is not possible to 'prove' that one approach to an understanding of the development of information technology curriculum is superior to another, and the case study examples included in this paper make no attempt to do so. What we have attempted to show in the paper is that using an ecological framework offers a useful means of understanding the complexity of the interactions involved in curriculum development. We leave it to the reader to reflect on whether their own experiences of curriculum change also fit with this model.

To further test the ecological model we are now moving outside the area of curriculum development and gathering data on the use of mobile phones and SMS by various groups of individuals and organisations to see if an ecological model could be useful in explaining this. The whole area of mobile computing also offers interesting possibilities for researching the application of ecological models. It may also be possible that consideration of these issues gives us a means of enhanced change management.

The use of such an ecological approach to IT curriculum innovation also offers an opportunity to improve the chances of its success. This can be achieved through the ways that the curriculum innovation might improve the balance between energy expenditure and satisfaction obtained, or succeed through co-operation, successful competition or filling a niche. If an academic wants to increase the likelihood that an IT curriculum innovation will be adopted we suggest using this ecological approach and examining the likely consequences. If these factors are taken into consideration while implementing the changes, the chance of successfully adoption will be enhanced.

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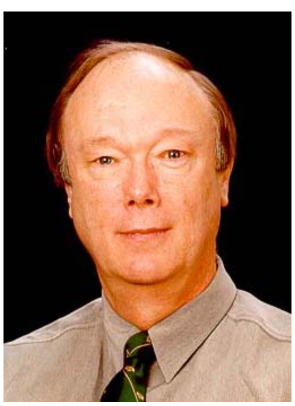

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