Final Report

The Collective Consciousness of Information Technology Research

Ways of Seeing Information Technology Research: Its Objects and Territories

Christine Bruce

Binh Pham

Ian Stoodley

2002

Acknowledgements: This project has been supported by a QUT ATN Small Research Grants Scheme and the Centre for Information Technology Innovation.

IT Collective Consciousness Project - Publications to Date

Technical Reports

Bruce, C., B. Pham and I. Stoodley. (2002). *The collective consciousness of information technology research. The significance and value of research projects. A. The views of IT researchers.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Res.pdf.

Bruce, C., B. Pham and I. Stoodley. (2002). *The collective consciousness of information technology research. The significance and value of research projects. B. The views of IT industry professionals.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Ind.pdf.

Bruce, C., B. Pham and I. Stoodley. (2002). *The collective consciousness of information technology research. Ways of seeing information technology research: Its objects and territories.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-WOS.pdf.

Conference Papers

Bruce, C. and B. Pham. (2001). Investigating ways of seeing IT research: a tool for facilitating effective research partnerships? In *Learning Partnerships.* Proceedings of the 24th International HERDSA Conference, July 2001, Newcastle, University of Newcastle, Australia: HERDSA. [CD-ROM] May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/HERDSA_.doc.

Pham, B., C. Bruce, and I. Stoodley. (2002). *Understanding and influencing a learning community*, presented at Lifelong Learning Conference, Yeppoon, June 2002. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/LLConf_.doc.

Journal articles

Bruce, C., B. Pham and I. Stoodley. Constituting the significance and value of research projects: Views from the information technology research community. Manuscript completed.

Pham, B., C. Bruce, & I. Stoodley. Ways of seeing IT research: Its objects and territories. Manuscript under development.

Abstract

The collective consciousness of effective groups of researchers is characterised by shared understandings of their research object or territory. In the relatively new field of information technology research, rapid expansion and fragmentation of the territory has led to different perceptions about what constitutes information technology research. This project explores a facet of the collective consciousness of disparate groups of researchers and lays a foundation for constructing shared research objects. Making IT researchers' ways of seeing explicit may help us understand some of the complexities associated with inter and intra disciplinary collaboration amongst research groups, and the complexities associated with technology transfer to industry.

This report analyses IT research, its objects and territories, as they are constituted by IT researchers associated with the sub-disciplines of information systems, computer science and information security.

A phenomenographic approach is used to elicit data from a diverse range of IT researchers in semi-structured interviews. This data is analysed to show (1) the variation in meaning associated with the idea of IT research and (2) the awareness structures through which participants experience variation in ways of seeing the object and territories of IT research. An Outcome Space represents the interrelation between different ways of seeing the territory.

Eight ways of seeing IT research, its objects and territories, were found: The Technology Conception, The Information Conception, The Information and Technology Conception, The Communication Conception, The Ubiquitous Conception, The Sanctioned Conception, The Dialectic Conception and The Constructed Conception. These are described in detail and illustrated with participants' quotes.

Finally, some recommendations for further research are made.

Before the research project commenced ethical clearance was obtained from the University Ethics Committee (see Appendix). At the interviews participants signed a consent form indicating their willing participation in the project (see Appendix).

Contents

Note: References following quotes give the interview number, transcript page number and approximate position on the page, from a to d e.g. '10.6b' refers to interview 10, page 6, section b. An 's' following the reference indicates that the quote is secondary data drawn from a related project.

1 Introduction

The collective consciousness of effective groups of researchers is characterised by shared understandings of their research object or territory (Bowden and Marton, 1998, p.196).

The question of what is conceived to be, or experienced as Information Technology (IT) research, and indeed what is considered to be excellent IT research is at present contentious. Since the establishment of information technology academic groupings in the 1970s, the boundaries of IT research have continued to expand. What may now be claimed to be IT research includes studies in areas as diverse as data mining, cryptography, database architecture, multi-media, e-commerce, information management and information science. As researchers become increasingly concerned with IT applications and users, research is also becoming increasingly multi-disciplinary, addressing issues which may be seen to belong to the domain of, for example, life-science, education, management and art. Researchers' understandings of the IT research domain are thus continuing to transform to account for the diverse needs of IT users. One participant in this study commented on the changing interests of IT research.

> *I think there's an orbit, a very loose orbit that we sort of bounce around, almost like a particle, and sometimes we're on the fringe and sometimes we're not and what is on the fringe at one stage suddenly becomes core later on. For example, human-computer interfaces, definitely social psychology, cognitive psychology, but now if it's helping me to build better systems, it's definitely seen within the core [of IT]. (15.4a)*

Amongst IT researchers, varied understandings of the research domain have the potential to either threaten the field through excessive fragmentation or to strengthen it through combined insights. The threat of fragmentation and consequent impact on the development of IT research is serious internationally, and particularly in Australia, given that Australia "lacks the large cohort of experienced (IT) researchers capable of tackling long term issues ..." (Goldsworthy, 1997, p.88) and considering the fragmentation of funding mechanisms for Australian IT research (Sara et al, 1998, p.75). In either case, a close investigation of the variation presently existing in IT researchers' perspectives is needed, to assist in moving towards, or facilitating, a shared understanding of the collective endeavour. This shared understanding of IT researchers' research object or territory characterises their collective consciousness.

The success of any endeavour is usually influenced by shared understandings of the nature of that endeavour amongst those people contributing to it. Such shared understandings may be said to be the basis of a groups' collective competence (Sandberg, 2000). In a workplace context, particular ways of understanding facets of work and its context create the distinctive cultures which give particular companies a competitive edge.

The question, "What constitutes IT research?" is clearly an important one. One response to the question is that IT research is 'constituted' by those engaged in the work. Information technology researchers see their research as belonging to the IT domain or 'territory' and, as they widen the scope of that research, they construct the domain. This report attempts an analysis of the domain as it appears to be being constructed by researchers in the field, but is not intended to be a comprehensive review of the research territory. It proposes a way of representing the dimensions of the collective consciousness that are emerging, revealing the expanding research territory and attempting to show how different ways of seeing the territory are associated with different interpretations of the research object.

> *… computer science in some sense is the central point of information technology and as a computer scientist I understand that. Other elements also have a domain of their own and an independence of computer science, so they should not be dominated by computer science. They have the same value and worth as computer science, but computer scientists will not value their worth in the same way. (15.4c)*

Brew (2001), in an investigation of conceptions of research amongst academic researchers, found four variations of conception:

1. Domino variation: Sets (lists) of atomistic things - techniques, problems, etc. These separate elements are viewed as linking together in a linear fashion. A process of synthesising separate conception elements so that problems are solved, and questions answered or opened up.

2. Trading variation: Products, end points, publications, grants and social networks. These are linked together in relationships of personal recognition and reward. A kind of social market place where the exchange of products takes place.
3. Layer variation: Data containing ideas together with (linked to) hidden meanings. A process of discovering, uncovering or creating underlying meanings.
4. Journey variation: Personal existential issues and dilemmas. They are linked through an awareness of the career of the researcher and viewed as having been explored for a long time. A personal journey of discovery, possibly leading to transformation.

Our previous research into the collective consciousness of IT research has also revealed similarities and differences between academic and industry researchers' ways of constituting the significance and value of research (Bruce and Pham, 2001; Pham, Bruce and Stoodley, 2002). These differences have the potential to enhance or hinder collaborative projects in the field. The research reported on here is the second phase of our Collective Consciousness research project.

2 Historical Phases of Information Technology Research

Our investigation of IT researchers' ways of constituting IT research begins with a review of its history. Bibliographic databases and library catalogues have been scanned unsuccessfully for material on the history of IT research. However, since there would seem to be a connection between the history of the development of IT and the history of the development of IT research (see further discussion in Section 11.1), a brief overview of the history of IT development follows, with a commentary on recent research interests.

A broad description of IT would interpret technological developments in writing (circa 3100 BC), printing (China circa 860AD, Germany circa 1450), telegraph (1837) and telephone (1876) as falling within the realms of the IT domain (dates from The New Britannica Encyclopaedia: Macropaedia). Adopting this broad view, Hall and Preston (1988) suggest three main phases of IT development:

1. Pictorial representation and written language technologies (paper, writing instruments, ink, printing presses), up to the 19th century;
2. New Information Technologies, comprising two related stages:
   a. Mechanical, electromechanical and early electronic technologies (telephones, typewriters, gramophones, cameras, tabulating machines, radio, television), in the late 19th and early 20th centuries; and
   b. Microelectronic technologies (computers, robots, information-handling equipment, office equipment), from the late 20th century; and
3. Convergent Information Technologies, consisting of:
   a. The integration of computers and telecommunications (in particular, switching equipment, transmission equipment, peripherals and wireless communication), from the 1970's onwards. Additionally, Preston (2001) observes that these technologies (amongst which he includes cable and satellite television, and video cassette recorders) were widely adopted throughout the world; and
   b. By the late 1990's digital technologies presented significant new advances in information processing and distribution, by means of "a growing technical 'convergence' of advanced telecommunications, computer and broadcasting networks".

Indeed, the converging of information technology, communications and broadcasting sectors in the 90's has had immense social impact. IT developments have influenced the economy, the nature of work, cultural values, our lifestyle and educational techniques, to name a few. Computer technologies are no longer seen as tools for a small community of specialists, but as being essential for all people. In higher education, the narrow focus of Computer Science (CS) on formal methods and abstract thinking has been broadened to encompass Information and Communication Technology (ICT) which includes not only the technical issues addressed by traditional CS areas, but a wider range of issues related to people's use of computer technologies (for example, the management of information systems and social impact) and communication systems.

The general aim of IT research is to seek better methods, systems and performance, however an urgent problem it confronts is also how to transform work practices and recognise further opportunities for innovation in other sectors such as business, science, engineering and government. Because of this, IT

applications are widespread and often provide impetus for further IT development. New technologies have stimulated a surge of new developments in many industries (for example, electronic publishing and remote sensing for mining and agriculture) and new industries, markets and employment patterns have emerged (for example, in e-commerce and multimedia production). In addition, political and economic pressures have forced universities to adopt an increasingly outward-looking attitude which encourages closer interaction with industry and the community, and new research areas have been created to cope with such demands.

Thus, IT research is becoming increasingly diverse and multi-disciplinary, and opinion concerning what is included in IT research remains controversial. Also, as users' varied needs are met, IT researchers' understanding of their domain is being transformed.

In considering researchers' understandings of the IT research domain, we would like to suggest a tentative link between the categories found in this research and the history of the development of IT research. This concept is elaborated on later in this report.

3 Aim and significance of the Project

3.1 Aim

The aim of this project is to investigate dimensions of the collective consciousness of IT research. In particular, this study investigates how IT researchers see:

- IT research,
- the IT research object and
- the IT research field, or territory.

The primary outcome from this study is a framework comprising a set of categories, each of which represents significant differences in IT researchers' ways of seeing IT research, its objects and territories. These categories represent different ways of seeing IT research from a broad perspective, without directly associating them with specific disciplines or sub-disciplines. The intention is not to classify specific researchers or groups of researchers, but rather to identify different ways of thinking that may change with the context in which they work. This allows researchers from the various groups to interact with the framework freely. In the course of the research, interaction with IT researchers from a range of disciplinary backgrounds ensured significant variation was identified.

The outcomes of this research include an explication of different ways of seeing the object of research, and different ways of seeing the territory, and a clarification of the relationship between these. Another outcome is the representation of the relationships between these ways of seeing in an outcome space. Finally, we have discovered that it is not possible to describe ways of seeing IT research independently of describing ways of seeing the research object and territory. The latter two are an integral element of interpreting variation in ways of seeing IT research.

3.2 Significance

Clear understanding of the different ways of seeing these facets of IT research is essential to the development of the field. IT researchers need insights into the commonalities and complementarities of their endeavour. These commonalities and complementarities essentially form the basis of IT researchers' collective competence and creates the distinctive culture of IT research. The significance of this study thus resides in its ability to:

- illuminate the expanding and changing ways of seeing IT research
- suggest directions for moulding the IT research culture into a cohesive rather than fragmented whole, and
- provide a systematic framework for research development strategies for novice as well as more experienced researchers, and lay a foundation for further investigation of IT researchers' collective consciousness.

4 Theoretical Framework

Understanding the collective consciousness of a learning community is an important facet of building that community. Bowden and Marton's (1998) framework of the university as a learning community involves both learning at the individual level, that is learning in the context of studying, and learning at the collective level, or research. Within this framework, learning is considered to occur when there is a change in awareness; when individuals or groups come to see some aspect of the world differently, thus widening the individual or community perspective.

Research communities are necessarily learning communities and we believe that understanding the character of these learning communities is critical to helping to build them. Bowden and Marton (1998) suggest that the partnerships and collaborations that are essential to healthy learning communities are possible only when participants share, or understand, each others' ways of seeing their research objects and territories. It is these ways of seeing that, when taken together, comprise the collective consciousness of a research community.

The domain of IT research, like any other research territory, could be seen as being continuously constructed by researchers participating in the endeavour. According to Bowden and Marton (1998), the collective consciousness comprises both "what is common and what is complementary" (p.194). It emerges when different people are conscious of the same phenomenon or object of knowledge, and are conscious to a greater or lesser extent of each other's ways of seeing, experiencing and thinking about the phenomenon. Clearly, the collective consciousness of IT researchers is in relatively early stages of formation, when compared with other disciplines. Nevertheless, IT research is already an interesting and important domain, comprising multiple perspectives. Bringing these differences and complementarities into the open, in the hope of enriching the collective consciousness, is a primary purpose of this paper.

For the purposes of this project, the term 'IT research community' is used to include the wide range of stakeholders that, nationally and internationally, participate in IT research. Our project focuses attention on a localised 'community of IT researchers' in order to begin to uncover one aspect of the collective consciousness the IT research community, that is, variation in ways of seeing IT research, its objects and territories.

5 Research approach

Since the early 1970s, phenomenographic approaches (Marton and Booth, 1997) have been used extensively, and successfully, to investigate variation in ways of perceiving or experiencing phenomena. The approach is now beginning to be used to investigate the collective consciousness of research communities (Bowden and Marton, 1998), in particular those of IT researchers (Bruce and Pham, 2001; Pham, et al., 2002), and materials science (Baillie, Emanuellson and Marton, 2001). The approach has also been used to examine research students' conceptions of literature reviews (Bruce, 1994, 2001), researchers' conceptions of research (Brew, 2001), and students' conceptions of research (Kiley, 2000).

Phenomenography is a description of appearances, it is "the empirical study of the differing ways in which people experience, perceive, apprehend, understand, conceptualise various phenomena in and aspects of the world around us" (Marton, 1994). Phenomenographic investigations explore the interrelationship between people and the world, striving to understand the way people look at, or are aware of some aspect of the world, and the way that aspect of the world appears to them. In this investigation, exploring ways of seeing IT research, its objects and territories, involves exploring the way in which IT research is looked at, or how it appears to IT researchers.

6 Participants

This section summarises the profiles of the research participants who were interviewed. Prospective participants were approached on the basis of their involvement in IT research, from the perspective of the research team, and to maximize the possibility of eliciting different ways of conceiving IT research projects.

Interviews were conducted with members of university faculties of Information Technology, Education and Health. The Faculty of Information Technology from which participants were drawn embraces a wide spectrum of interests within IT. Research topics include robotics, artificial intelligence, security, information management, multimedia, software engineering, library and information sciences and IT education.

Table 1: Profiles of participants

Gender		Age				Sub-discipline				Research experience	
M	**F**	**<30**	**31-40**	**41-50**	**51+**	**CS**	**IS**	**DC**	**Other**	**Ear**	**Exp**
12	5	1	4	5	7	2	4	5	6	5	12

Key to abbreviations
Sub-discipline: CS = Computer science, IS = Information Systems, DC = Data Communications.
'Other' sub-disciplines were described as: Education, Social Medicare, Mathematics Education, Business and Social Psychology.
Research experience: Ear = Early, Exp = Experienced.
Research experience other than IT was described as: Management of applied research group, Market analysis, Software development.

Of the 17 participants, 12 were male and 5 female. They ranged in age from the twenties to over fifty.

A range of sub-disciplines were represented by the participants, including Data Communications, Computer Science, Information Systems, Social Medicare, Business and Social Psychology.

Five considered themselves early career researchers (having completed their PhD in the last five years), and twelve were more experienced.

7 Data gathering and analysis

Semi-structured individual interviews of approximately 30 minutes each were conducted with volunteer IT researchers. These conversations served as opportunities for encouraging participants to articulate their views. Questions were designed to elicit variation in ways of seeing IT research. They were designed to be broad enough to obtain meaningful responses in relation to the aim without forcing a particular structure, or way of responding, upon participants. Each question served as an 'opening', from which the interviewer developed a trail of further questions in order to achieve a shared understanding of the participants' perspectives. The questions were trialled during a pilot study in August 2000. Data gathering for this study was conducted between June and December 2001.

The questions used to facilitate discussion with researchers about their views of what constitutes IT research were:

1. Describe your area of research. Is this IT research? Explain what makes this IT research.
2. [In relation to five abstracts supplied.] How do you decide whether these studies represent IT research or not?
3. What is it about them that would help you decide?
4. How do you in general decide if someone is doing IT research, or not?

After completion of the interview, tapes were transcribed verbatim and checked by the interviewer. Copies of the interviews were sent to the participants for information and comment.

The analysis of the interview data was an iterative process involving a team of three researchers. In keeping with existing views of phenomenographic analysis, the process is considered to have commenced during the interview when the interviewer sought to understand the interviewees' ways of seeing IT research. After transcription of the interviews, the research team focussed on analysing the data. Extracts which indicated substantial variation in conception were selected for analysis from the interview transcripts. Analysis involved seeking (1) the variation in meaning associated with the idea of IT research; this variation is referred to as the referential component of the categories of description and is described in subsequent sections of the report and (2) an understanding of the awareness structures through which participants experienced IT research; these form the structural component of the categories of description and are also further described in subsequent sections of the report.

In order to contain the scope of the study, this investigation was geographically confined to South East Queensland.

7.1 Conceptual framework guiding analysis

The conceptual framework presented here has evolved through the course of the analysis. That is to say, the conceptual framework guiding the analysis was continually reviewed and modified in response to the character of the phenomenon under investigation.

As in any phenomenographical analysis, the guiding principles were to uncover the referential and structural components of the phenomenon. These would be presented via the categories of description and outcome space. In the course of the analysis we found that it was not possible to describe the ways of seeing IT research separately from describing the ways of seeing the object and the territory. The data itself, therefore, suggests that the ways of seeing the object and territory constitute the ways of seeing IT research. Therefore, the ways of seeing IT research are presented as the referential elements of the categories of description; and ways of seeing the object and the territory are presented in the associated structural component of the categories.

The point of departure for our analysis involved the following questions:

- IT research: How do IT researchers see IT research?
- The IT research object: How do IT researchers see the 'things' underpinning their research? How do they collectively constitute or 'shape' the object of IT research? What kinds of shared understandings do they have of their research object? How do their understandings differ?
- The information technology research field, or territory: What are the features of the field? What are its boundaries? What comes to the fore and what recedes to the ground?

Clear relationships between researchers' ways of seeing the objects and territories emerged. In particular, ways of seeing the object are apparently aligned with particular ways of seeing the territory.

7.1.1 Categories of description

During the course of our analysis we investigated different ways of seeing (or conceptions) amongst the community of IT researchers (the subjects) in relation to IT research (the object). The goal is to describe the varying internal relations between the subject and the object. This can be represented diagrammatically as shown in Figure 1.

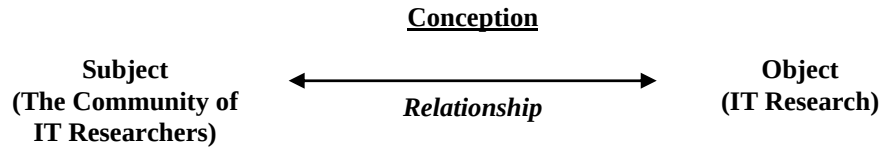


Figure 1: Graphical representation of a conception

The participants expressed various conceptions during the course of the interviews. These conceptions (different ways of seeing what constitutes IT research) are presented as discrete categories of description. Each category of description is comprised of two interrelated parts:

1. a referential component in which the meaning of the category is captured. This is visible in the title of the categories and the descriptions accompanying them.
2. a structural component which describes how relevant parts of the world are seen and are related. It is here that the structures associated with the referential component are made explicit. This is represented in the specification of the object (focus or internal horizon) and territory (the object and external horizon) of each category. A symbolic representation identifying, or establishing the relationships between, the dimensions in focus is also provided.

Each category of description begins with a description of the meaning of the conception associated with that category, including definitions of information and technology as they are seen in that conception, this is followed by a description of the research object and then a description of how the territory of IT research is constituted in that category.

7.2 Observations during the course of the analysis

It should be noted that a project may appear as IT research for different reasons by members of a research community.

For example, one project appears as IT for different reasons by the following participants:

> With respect to 'Integration of stereo and shape from shading using colour' (see Appendix 14.5) -
>
> *… this is definitely a paper that everybody will agree is in robotics … we can consider it an IT program, because for robotics … a lot of problems are software problems not other problems - and a software problem is an IT problem. (7.1d) [Category 1]*
>
> *… this seems to be about graphics, I think … and yes it seemed to me definitely IT research … it's processing information … (2.4b) [Category 2]*
>
> *… the technology being involved in the understanding of these shapes and colours … I would class this … as an IT project … it does involve the interface of looking for information through the technology. (9.3b) [Category 3]*

Also, a project may appear to be IT or appear not to be IT by members of the same research community:

> With respect to 'An array processor architecture for support vector learning' (see Appendix 14.5) -
>
> *… it certainly is talking about algorithms … so anything to do with algorithms is to me to do with computer science and to do with processing information ... (2.3b)*
>
> *… 'algorithm' starts to get more towards the mathematics side … that would fit into a mathematical research area … (4.5a)*
>
> With respect to 'Business process re-engineering' (see Appendix 14.5) -
>
> *… I'm quite comfortable with that because I see it talks about the social implications for the future and … having just said that information technology is to do with information, which is a human function, when I see social implications, I would say, "Yes, that's going to be IT research" … (8.2d)*
>
> *This certainly is marginal, I would say … it seemed to be a lot more to do with … management … than to do with any information processing … you can see the term 'IT' there all the time, but this research seems to be much more about the business impact of IT rather than IT itself. (2.3b)*

At times, as participants endeavoured to express their views, they slipped between the categories that have been identified here.

> With respect to 'Conceptions of an information system and their use in teaching about IS' (see Appendix 14.5) -
>
> *… this is information systems and information systems research is IT … I think, if we have a broad view of what constitutes IT research, we can accept this as an IT paper. (7.2b)*
>
> *… For me, what I would call IT research is something that improves the existing technology and … yeah, I'm not convinced that this paper is making any contribution in this direction. (7.2d)*
>
> *… for me all are IT papers …(7.3a)*

The variations represented here are precisely the kinds of variations for which we wished our analysis to account.

7.3 Defensibility of outcomes

In phenomenographic research, defensibility or trustworthiness may be established within a phenomenological framework. Criticisms of phenomenographic research on the basis of lack of validity, lack of predictive power, researcher bias and denial of the voice of the individual through categorisation (Bowden 1995, p.145) have led to increased attention being paid to the need to establish the trustworthiness of the outcomes (Bowden 1995; Gerber 1993; Sandberg 1994, 1995a, 1995b). The trustworthiness of the outcomes of this study is based on approaches established by Saljo (1988), Gerber (1993) and Sandberg (1994, 1995a) whose thinking contributes to an understanding of what is required to ensure sound outcomes of a phenomenographic study. These researchers suggest that outcomes of a phenomenographic study could be said to be sound where:

- there is a demonstrable orientation towards the phenomenon (in this case, the ways in which the significance and value of IT research appears to a research community) through the process of discovery and description,
- they conform to the knowledge interest of the research approach, in this case interest in the appearance of the phenomenon and
- they are communicable to others.

The trustworthiness of this study was established through meeting the above criteria.

8 Ways of Seeing Information Technology Research, its Objects and Territories

Each way of seeing found in the course of this research is represented by a category of description. In all, eight different ways of seeing IT research were identified:

1. The Technology Conception,
2. The Information Conception,
3. The Information and Technology Conception,
4. The Communication Conception,
5. The Ubiquitous Conception,
6. The Sanctioned Conception,
7. The Dialectic Conception and
8. The Constructed Conception.

These ways of seeing are not intended to capture the views of individuals, in the sense that individuals cannot be aligned with any one of the categories. Each individual may be expected to adopt one or more of the ways of seeing in relation to a particular project at a particular point in time.

9 Outcome space

While the categories of description represent the varying ways of seeing discovered amongst the participants, the outcome space represents the relationship between those different ways of seeing. The outcome space is thus constructed to depict the way in which the parts can be related to form a whole picture of the different ways of seeing amongst the participants interviewed. It represents the phenomenon of IT research as it is seen by this group and presents an experiential framework for thinking about the nature of what constitutes IT research amongst IT researchers.

Outcome spaces have, in different projects, been found to represent historical views of a phenomenon, to represent a widening awareness or to represent a hierarchy of increasing complexity and sophistication. In this study the outcome space divides into two parts – one appearing to reflect the historical development of the discipline of IT to the present and the other appearing to reflect the emergence of as yet unarticulated aspects of the discipline. These two groupings of categories indicate completely different ways of approaching or seeing IT research. In the former, the relationship between the research community and the object or territory is passive. In the latter the relationship between the research community and the object or territory is active. It appears that the process of discipline development is continuing to emerge and is being made visible through this project.

Key components of this outcome space are depicted in Table 2. Some details of the variations shown in this table are explained in the next section, Categories of Description.

Table 2: Key components of the outcome space

#	Category	Focus	Territory	Information	Technology	Active/ Passive	Group
1	The Technology Conception	T	Constructed in relation to technology	Unclear	Hardware and software	Passive	Historical development
2	The Information Conception	I(T)	Delimited by interest in information processing	Sophisticated, but meaning unimportant	Unclear	Passive	Historical development
3	The Information and Technology Conception	I+T	Information and technology simultaneously in view	Sophisticated, but meaning unimportant	Information processing techniques (includes books)	Passive	Historical development
4	The Communication Conception	I+T+H	Includes communication with human beings	Sophisticated, meaningful to human beings	Information communication techniques (includes systems design)	Passive	Historical development
5	The Ubiquitous Conception	U	All endeavours that use computers	Low and high levels of sophistication	Hardware and software	Passive	Historical development
6	The Sanctioned Conception	S	Delimited by other people's perceptions	Low and high levels of sophistication	Unclear	Active	Agency
7	The Dialectic Conception	D	The purposes of the researcher interact with existing structures	Unclear	Unclear	Active	Agency
8	The Constructed Conception	C	Limited only by the perspectives of IT researchers	Unclear	Unclear	Active	Agency

The Historical development group focuses on the interrelation of the elements of IT research with each other and with human beings in general. The progression from Category 1 to Category 5 seems to parallel the development of IT from its earliest stages through to the present time.

> *We moved out of the idea of having stand alone computer systems in the late 60's, early 70's, and never looked back. So the web is simply an extension of a process that started back then when people started connecting computers together and connecting terminals to computers. So having data communications projects under the umbrella of IT is just part of that extension. (3.2c)*

The initial five categories identified seem to reflect the emphases in the development of IT research, thus:

Category 1. Technology: Focussing on the foundations upon which information technologies are built - the machinery, software and systems that make information processing possible.

Category 2. Information: Once the fundamental technologies were sufficiently developed, attention turned increasingly to the information which they processed.

Category 3. Information and Technology: In time, the interaction between the technology and the information processed by that technology came into focus more.

Category 4. Communication: As the use of IT expanded, questions were asked about how it could be improved for the betterment of human beings.

Category 5. Ubiquitous: With the existing pervasiveness of the use of computers, this way of seeing is considered to reflect the present state of play in the evolution of IT as a discipline.

The Agency group focuses on the interaction of the IT research community with IT research. In other words, in Categories 1 to 5 the researcher is interacting with the elements of IT or being acted on by these elements and this is having a positive or negative effect on the researcher, however the researcher does not express any consideration of whether they or others have an influence over the definition of IT research as such. On the other hand, in Categories 6 to 8 the researcher expresses an awareness of how they or others relate to IT research, not just in the sense of being engaged in it but also in the sense of actively delineating what it is they are engaged in, and see themselves as more or less in control of the research territory and responsible for its definition. These categories (6 to 8) seem to push towards the reconstruction or emergence of new facets of the territory.

10 Categories of Description

10.1 Category 1: The Technology Conception

10.1.1 Meaning

In this category IT research is seen as research that attends to, is oriented or directed towards, technology.

According to this way of seeing, research includes a range of activities, such as the manufacture of technological artefacts, the development of new systems, the writing of mathematical formulae and the creation of programming code. Researchers who see IT research in this way consider technology to be the defining element of IT research. For these researchers, the appearance of keywords and phrases such as 'hardware', 'software', 'computing science', 'systems design', 'algorithm' and 'programming' indicate inclusion in IT.

Researchers see themselves as being in a passive relationship with IT research in as much as they are not in the process of defining IT research, rather they are responding to an existing definition.

> *… of all the ones, this one here … seems to fit into classic computing science … it's got all the right words which you'd find typically only in IT. So, 'object oriented analysis and design', and it mentions 'programming language' and 'encapsulation' and 'classes' and that sort of thing. I mean, that's got a lot of key words there associated with … classic computing science type issues. (3.5a)*

> *… I have a very pure definition of IT research … which is that it … it is … developing the computer whose keystrokes will work out whether you're writing nasty or mean things about your boss or not … So, I think that's IT research, whereas … the social implications of IT development … could be done by a sociologist or by an IT person. (12.7b)*

> *… for me IT is programming and maths and stuff like that … (14.2c)*

10.1.1.1 Information

The interpretation of 'information' and 'technology' varies from category to category.

In this category a clear approach to information is not enunciated by the participants articulating this way of seeing, which suggests that it is insignificant in this view of IT research, relative to the more prominent status of technology. Information in this category appears to be interpreted by the researchers as having a wide range of sophistication, including the most fundamental raw data level. Issues of the nature of the information processed, important in other categories, appear to be irrelevant here.

10.1.1.2 Technology

Technology in this category is interpreted by the participants as the hardware artefacts of IT and the software and systems that control them.

> *… extending and developing software to solve problems in software. (1.3a)*

> *… algorithms, software, hardware, might be a way to classify things and one could look for any of those … (2.5c)*

> *… I see the word 'programming' in the second line and I see the word 'computationally intensive', so I wouldn't disagree that it was IT-based … (8.2c)*

10.1.2 The research object

The focus of IT researchers in this category, their research object, is Technology. This focus may be represented as follows:

T (Technology: artefacts, software, systems)

Technology is delimited as the artefacts of IT, the programs or languages that control these and the systems they construct.

> *Software is ... the development of software, the core task for IT … it's definitely IT. (5.6c)*

> *… what I would call IT research is something that improves the existing technology … (7.2d)*

> *[What helped you decide, "Yes, this is definitely IT"?]*
> *I was looking for the extent to which technology was an integral … intrusive, almost, part of it, rather than a background, invisible element. (9.4a)*

> *… we obviously think of information technology as being skilled in using systems, computer systems … like hardware and software, designing systems … based on technology … (13.4c)*

One researcher expressed the opinion that the distinction from applications needs to be carefully maintained.

> *Information technology … in my definition is quite strict. It is that technology that produces artefacts which are useful in the information environment, which can incorporate such things as basic technologies in the data communications area - let's be specific, the artefacts of it would be routers, switches, computers … It would not be, for example, a medical information system. That would be an application of information technology – a usage of an artefact, computer, an artefact, software, to create an application called 'medical information system' … Just like the axe is used to carve the boat. The axe, the artefact, made the boat. … At each point in that chain, of course, 'technos' comes in. Technology comes in because you've got the axe maker who knows how to make the axe. He gives the axe - and there's this guy who wants an axe – the artefact, the axe. So the builder of the boat says, "Oh good, I can use that." Now, 'technos' comes in again. I know how to use an adze or an axe to hollow out a boat. Knowledge – 'technos'. But now it's boat-making, not axe-making. (4.9a)*

In a number of the categories it is difficult to discern what is in the background, it often seems that the perceptual boundary is delimited by the focus.

10.1.3 Constituting the territory

The territory of IT research in this, as in other categories, mirrors participants' views of the research object. The territory of IT research is seen in this category as constructed solely in relation to technology.

> *I would see core IT as being … engineering-IT developments of new hardware and software, leaving it fairly open where those systems, software, hardware might ultimately end up … (17.4b)*

This way of seeing, with its exclusion of application from IT, provides a clear contrast with other categories of description which incorporate a breadth of application in their understanding of what IT research encompasses. Here the application is in the ground, or may be one of the elements in the ground.

In this way of seeing, the historical roots of IT are seen as continuing to inform the essential character of the field. Thus, this includes foundations in mathematics and engineering as well as other areas of study, such as machine learning, which have been associated with IT over a reasonably long period of time.

> *… machine learning … has got some historical links with artificial intelligence. How you learn new information, how you build algorithms to learn and how you get computers to learn things, and then how … you go about representing information are part and parcel … historically are topics … I've never questioned that they weren't part of information technology. (3.4c)*

> *[… what helped you decide that they were definitely IT?]*
> *Because they seemed to be focusing on traditional notions of information technology … we obviously think of information technology as being skilled in using systems, computer systems … like hardware and software, designing systems … based on technology … (13.4c)*

> *What helps me decide? I guess it's my picture of what information technology is … my picture of it is programming and mathematics kind of mixed together … because that's how a lot of IT faculties were born … out of mathematics faculties … and … IT faculties and engineering faculties are very closely aligned … whereas the other fields like business and education … they have other affiliations (14.3a)*

This way of seeing embraces the foundations upon which information technologies are built, the machinery, software and systems that make information processing possible.

10.2 Category 2: The Information Conception

10.2.1 Meaning

In this category IT research is seen as research that attends to, is oriented or directed towards, information processing.

According to this way of seeing, research that attends to information processing includes a range of activities oriented around information, such as the security, organisation and storage of information. Researchers who see IT research in this way consider the manipulation of information to be its distinguishing feature. Thus, information processing is the focus of attention. Technology is in the background and serves only as a tool for achieving the core purpose of IT.

Researchers see themselves as being in a passive relationship with IT research.

> *… IT research … is actually looking at that actual information that you're dealing with. That's fundamentally what we do in our Centre. … we're not doing scientific investigations for a scientific goal like you might have in chemistry or physics, we're trying to deal with developing them to do with protecting the information with the very technology itself. (1.5b)*

> *I think the obvious way to say is: It's processing information. (2.2d)*

> *… if we're talking about technology research, well that's different, or computing or something else, that's different, but IT … I mean, the very purpose of it is the information, and the technology I see as the means … therefore if it's just purely technology stuff that doesn't relate to … identifying the nature of information, I don't see that it is IT. (9.4b)*

> *… information technology which is provided through computer systems is a way in which a lot of technique is brought together. … it's the … process by which our way of thinking is put into place in the world around us more and more. So, it's a way of organising our world, organising information. (11.4c)*

One participant saw concerns about the content of the information as being outside the scope of this way of seeing.

> *… IT people are primarily interested in the processing of information, not necessarily what the information is about. (10.5c)*
>
> *So, we had a student for example a while ago doing a PhD on ecological modelling and she was basically doing IT research because she was not actually terribly interested in the information itself and whether it was accurate or anything else. She was just thinking, "How can you take large amounts of information … ecological information and process it?" What are the characteristics of the information in terms of, if you like, the logical and physical characters of the information, not the meaning of the information - not whether it was right or wrong. (10.6a)*

10.2.1.1 Information

Information in this category is interpreted by the participants as having a reasonably high level of sophistication, beyond signal processing.

> *… it's arguably a little bit low level … in terms of dealing with … low level information … rather basic information and clearly there's a point where that becomes more just … signal processing which you … could argue was more … electronics or physics or engineering … but I would say that this is high enough that it is to do with IT, to do with processing of a reasonably … high level of information … that is its fundamental … focus and it's to do with all these sorts of things like … algorithms and things like that, which you would normally associate with IT when you're dealing with that level of information. (16.2a)*
>
> *… there's a point at which some very basic … signal processing, although it's about … technology and information, the processing of that information, it's a very … low level IT. … I think that because it's a very low level of IT that traditionally that's regarded as … belonging to the engineering, electronicsy sort of area. (16.3a)*

This contrasts with Category 1, where the nature of the information processed is not a concern.

10.2.1.2 Technology

Technology in this category is not clearly interpreted by the participants but includes the hardware artefacts of IT and the software and systems that control them. The fact that a clear definition of technology is not enunciated by the participants indicates that it is relatively insignificant in this view of IT research, as compared with the more prominent status of information.

10.2.2 The research object

The focus of IT researchers in this category, their research object, is Information, with Technology in the background. This focus may be represented as follows:

I(T) (Information (Technology))

Technology is seen as a tool used to manipulate information at a reasonably high level. Thus, for research into technology to be included in IT, it must have direct application to the processing of sophisticated information.

> *… from my point of view … you could I suppose see some mathematics research, if it's oriented to solving a mathematical problem which is then going to have application for IT, then you could understand why people might call it IT research. But it's at least one step removed. … I did my first and second degrees … in linguistics which is an area which tends to contribute a lot to areas like artificial intelligence and I could do research in linguistics which I think might ultimately be quite interesting for people working in artificial intelligence, but I couldn't say that it was a IT problem. You know, I couldn't say that it was IT research until I decided to … apply it to information processing problems. (10.5c)*

10.2.3 Constituting the territory

The territory of IT research in this category is very different from that represented in Category 1. The IT research territory is seen as delimited by interest in information processing, and so research that is not about information processing is not IT research. Thus, in this view, research into technologies may only be considered to belong to the field of IT research if that research is targeted at the processing of information.

> *… I'm looking specifically at information, so I'm limiting technology by information. … I think … researching programming languages … researching a piece of software … looking at the ergonomics of … how one sets up a system in an office … is not IT, it's more technology research. So the architecture of the systems within there [points to a computer] is more technology rather than information technology. (9.5b)*

This way of seeing contrasts with the preceding category, where application is not included as lying within the realms of IT research. In this category application to information processing is considered to be integral to IT research.

This view also contrasts with the preceding category in as much as technology here is unobtrusive, relegated to a background role as a means to accomplish what is understood to be the central function of IT (which is information processing). The same distinction forms a contrast with the following sections, in which technology takes a more prominent position alongside information (and other elements).

In this way of seeing, the use to which the technology is put (that is, the processing of information) is seen as defining or delimiting the essential character of the field. Therefore, research into technology which does not include acknowledgement of the function of the technology, and more specifically which does not apply to information processing, is not seen as being IT research.

10.3 Category 3: The Information and Technology Conception

10.3.1 Meaning

In this category IT research is seen as research that attends to, is oriented or directed towards, both information and technology.

According to this way of seeing, research that attends to both information and technology includes activities such as information collection, information provision and information security. Researchers who see IT in this way consider the convergence of information and technology as integral to IT. Research into technology or information in isolation from the other is not considered to be IT research.

Researchers see themselves as being in a passive relationship with IT research.

> *… maybe we're more clearly cut that we're in information technology in our Centre because we're dealing with the information. We're applying technology solutions to protecting information. (1.5a)*

> *… IT is much more than information technologies but as the basic grounding, I suppose, looking at gathering and dissemination and selection of information using technologies. Now … theoretically that could cover just using books and that sort of thing … I work with teacher librarians … who are the information technology specialists in the school very often, but it's more information literacy and the technology is an element of the information literacy aspect. So that … the technology comes in where you've got a mechanical interface of some sort, I guess. (9.2b)*

> *[What makes it IT research, from your point of view?]*
> *I guess the fact that we're dealing with … information and computers and the processing of the information in a … mechanical or artificial way … (16.1b)*

10.3.1.1 Information

Information in this category seems to be interpreted by the participants at a sophisticated rather than lower level.

> *We're applying technology solutions to protecting information. (1.5a)*

> *… it pertains to something that helps us understand … the way information is stored or retrieved, selected - all those literacy type things - within a technology environment. (9.4c)*

However, the meaning of the information is not important in this category, just the processing of it.

> *… we had a student for example a while ago doing a PhD on ecological modelling and she was basically doing IT research because she was not actually terribly interested in the information itself and whether it was accurate or anything else. She was just thinking, "How can you take large amounts of information … ecological information and process it?" What are the characteristics of the information in terms of, if you like, the logical and physical characters of the information, not the meaning of the information - not whether it was right or wrong. (10.6a)*

10.3.1.2 Technology

Technology in this category is interpreted by the participants as any application of technique to information processing, therefore it may include books and symbols as well as computer hardware and software. The framework of technology in this category is therefore wider than in Category 1.

> *… the technology environment could possibly also be books. Does it have to be electrical? Does it have to be electronic?*
> *[Ok - you want to talk about that a bit more? Would you include printing in IT?]*
> *Not normally, but I think in theory it can be. … very often 'information technology' is used instead of 'information literacy', I think. So, information literacy is perhaps the broader term that specifically includes … the print materials. Then, of course, you have print materials on little e-books and things don't you?! So … there's a very fine line between technology and not technology. Certainly … technology has been used to produce the book. And if they're in technological format then perhaps you can do more with them in searching for information within them. (9.4c)*

> *… my definition of technology is much broader than IT … technology … is not just information technology … It's also very basic tools … it's also to do with knowledge and skills development, and it's also to do with the larger framework of technology, which is what I would call … technique or the construction of systems. …For me, information technology is … (long pause) a technology of information provision and the technology is not just computer-based presentation of information – or its organisation – but also can be … a language … it can be a written form, it can be symbols. … Research into information technology would be the various forms and experiences associated with the provision and understanding of the way in which information is presented. So, it might be computer-based … but … for me, it's broader it's about information literacy – that is, understanding information as it's presented in all its different forms. (11.1d)*

10.3.2 The research object

The focus of IT researchers in this category, their research object, is the simultaneous attention to both Information and Technology. This focus may be represented as follows:

I+T (Information and Technology)

Research which is interested in information must at the same time relate that information to technology, for it to be IT research, and research which is interested in technology must at the same time relate that technology to information, for it to be IT research.

> *… because IT is two words … there's that link between the two - that it can't just be technology per se and it can't be just information per se but one's going to lead to the other. (9.4a)*

10.3.3 Constituting the territory

The territory of research in this category combines the territory of Category 1 and the territory of Category 2 to include both information and technology. It is more than the sum of these two categories, however, with the definition of technology expanding to include a far broader range of human activity than was incorporated in the first two categories and with the interaction of these two aspects of IT coming into focus to a greater degree. Researchers who see IT in this way consider the convergence of information and technology as representing the central character of the field.

This way of seeing contrasts with the previous category in that the application of technology to human pursuits expands to a wider range of activities. It contrasts with the following category in that the application to information processing there includes its impact on human beings.

This way of seeing also contrasts with the previous category in that the information processed is of a higher level. It contrasts with the following category in that the meaning of the information in the next category is central.

In this way of seeing the convergence of information and technology are seen as essential to the definition of IT, and thus forms the essential character of the field. Therefore, research which disconnects either technology or information from the other is not seen as being IT research.

This view acts as an intermediary position between the preceding and following categories, suggesting a continuum in the perception of the integration of information, technology and human beings.

10.4 Category 4: The Communication Conception

10.4.1 Meaning

In this category IT research is seen as research that attends to, is oriented or directed towards, the experience of communication with human beings.

According to this way of seeing, research that attends to the experience of communication with human beings includes activities such as the development of more efficient information exchange techniques, methods of information transfer, the facilitation of human thinking and the support of learning. Researchers who see IT in this way see human beings and communication as central, the mediation of information to humans is a critical element. Therefore, enabling effective communication is of core interest to IT researchers. IT research is seen to focus not just on information, nor only on the technology, nor even solely on human beings, rather it targets the interaction between technology and human beings, in terms of the quality of information exchange that is taking place.

Researchers see themselves as being in a passive relationship with IT research.

> *[What helps you decide whether they're IT or not? What do you see there, or what are you looking for?]*
> *I guess a continuum from people's understanding at one extreme, to some kind of physical technology at the other extreme. So … for it to be IT, I think it's probably got to go beyond a description of how you put chips together on a board, unless it's done for a specific purpose and … you're trying to explore, "If I put the chips together in this way or if I invent this new chip will that enable communication to go up?" … there has to be some form of intention to improve communication with a human being - that's what makes it IT. Working out whether the chip goes better or worse at various temperatures … I might try to … make a link there and say if a chip's working better it can communicate better, but I'm not – I think that would be pushing it beyond the bounds of reasonable … that would be an academic exercise. … So … does the research consider the potential learning that the human being at the end of the chain can use? (8.3d)*

> *… I take on board the human aspect … I'm interested in the people side. So that, for me, information technology brings in that … people side. (9.5a)*

> *[Let's say we're developing a search engine. What elements of that go outside of the IT area and what elements of that are simply technological?]*
> *It becomes IT when – to my mind – when you've got a person trialling it. And … so it's the interaction between what's going on in the mind of the person and the information that's being presented by the technology. (9.5c)*

> *Research into information technology would be the various forms and experiences associated with the provision and understanding of the way in which information is presented. So, it might be computer-based … but … for me, it's broader, it's about information literacy – that is, understanding information as it's presented in all its different forms. … IT research should be about the way in which information is provided and projected and understood … (11.1d)*

> *This, again, is fundamentally an IT area, but once more we have to remind ourselves, why is an IS system being developed and who are the intended users? So … it needs also to link back to intended users and develop systems that they can actually apply. (17.3a)*

In a similar way to Category 2, in this way of seeing technology is viewed as a tool to enhance the communication of information to human beings, however, in contrast to Category 2, in this category technology is much more in the foreground and a focus of attention for research.

> *… the research would pertain to understanding better how information and technology interact, and how people … use the technology effectively to get information. (9.4a)*

> *… it's thinking tools for man really … Anything to do with thinking tools for man. So it's not that you're looking at people. It's not that you're programming computers, it's the purpose that you are doing it for … to improve the tool in the long run, and its application … (12.11d)*

> *… IT is doing the research, to focus on how to produce a better thinking tool … (12.12a)*

One participant's perspective included how the information was used.

> *… information technology … is … the constructive and critical use of information that is enhanced by the use of efficient technology … It encompasses more than just the software and the hardware … but it also looks at the nature of the information, how the information is … communicated, how that information gets used, how it gets abused, how it enhances learning, how it doesn't enhance learning … (13.6d)*

10.4.1.1 Information

Information in this category is interpreted by the participants as having meaning to human beings, so they can learn from it or work with it in some way. Therefore, information here has a reasonably high level of sophistication that seems to exclude low-level data exchange. This contrasts with Category 1, where the nature of the information processed is not a concern, and with Categories 2 and 3, where the meaning of the information processed was not important.

> *It's a matter of the difference between information and knowledge ... and the technology is providing information, quicker, faster, more efficiently, more effectively … greater volume, etc, etc, etc. So there's that aspect, of getting that information into the human brain so the human brain can then generate knowledge. (8.5c)*

> *… the latest technology, per se, is not necessarily IT. It's clever, but it's at the end of the spectrum of inventing new bits of hardware … I'm personally more interested at the other end of what comes out of the hardware – or hardware/software – and communicates with the human being. (8.10a)*

> *… the research would pertain to understanding better how information and technology interact, and … how people use the technology effectively to get information. (9.4a)*

> *I tend to mainly focus on how children think and learn from the point of view of improving the thinking and learning of children than to improving making better computers. (12.2a)*

10.4.1.2 Technology

Technology in this category is interpreted by the participants as including any machine or system that enhances communication of information to human beings.

> *… if, for example, I'm using audio tapes, or even video tapes, it's a form of information technology in so far as some kind of electronic technology is being used to mediate information to a learner. (8.1d)*

> *… it could be anything from low temperature physics and the operation of microchips, if the intention is to improve the communication of information at a later stage, right through to how are things presented on a screen that makes it easy for the user to obtain the information. So, anywhere between those two ends of the continuum … (8.7c)*

> *… it might be computer-based … but … for me it's broader, it's about information literacy – that is, understanding information as it's presented in all its different forms. (11.1d)*

> *… mathematics and science came together … because mathematics had thought of the logic behind the computers … a hundred years before the technology was available through valves and things to do it and then they produced this tool … that can be an aid for human thought and since it's so important … a new science has built around it … which really is mathematics and … so … IT engineering is probably where … you'd actually make the … things and IT itself was where you'd think more about the theories and behind its structures and how it's used and … software programming to make it and … ways of systematising and build systems around it. … So … yes, it's a new one. It's an amalgam, an amalgam of different things. An amalgam of mathematics and science … (12.9d)*

10.4.2 The research object

The focus of IT researchers in this category, their research object, is discerned in terms of the simultaneous attention to Information, Technology and Human beings, this being defined here as 'Communication'. This may be represented as follows:

I+T+H (Information and Technology and Human beings = Communication)

Information, technology and communication are seen as being equally important.

> *… perhaps we're now working towards a hierarchy here, where we have technology which is the chips and the … printed circuit boards … then we have the information technology, so we have technology that is actually able to mediate information and that forms part of a system to provide information to human beings and we're now looking at how human beings interact with it [an information system]. (8.2d)*

10.4.3 Constituting the territory

The territory of research in this category expands to include communication with human beings. The complex web of relationships between humans, technology and information and the impact of information technology on humans give richness to this way of seeing.

Researchers who see IT in this way see human beings and communication as central and thus constituting the essential character of the field. This way of seeing contrasts with the preceding category in that it includes human beings. It contrasts with the following category in scope, in that the next category sets no limits on IT research whereas this category focuses primarily on communication with human beings.

10.5 Category 5: The Ubiquitous Conception

10.5.1 Meaning

In this category IT research is seen as research that attends to, is oriented or directed towards, issues associated with the application of technology to all human endeavours.

According to this way of seeing, research that attends to issues associated with the application of technology to human endeavours includes activities such as algorithm development, technology selection, skills for using technology and legal issues. Researchers who see IT research in this way consider all aspects of initiating and maintaining an IT system to be of interest to IT researchers, whether it be hardware or software development, the operation of IT systems or the social implications of IT. IT methodology applied to an otherwise non-IT field may also be considered to be IT research.

Researchers see themselves as being in a passive relationship with IT research.

> *I'm not sure that anybody has ever clearly drawn boundaries around what IT research is … So … there's an IT component pervades everything … (3.2a)*

> *I think it's probably … broad … I think it's now the world, so all things, they are all related to IT, so the topic is really broad … so it could be anything like how to solve … one small algorithm problem … or … teaching IT or … management in IT. It could be anything … (6.3c)*

> *The analogy that I would give, that a computer is purely a(n) … inanimate object and without the knowledge and skills to use it, it's useless, essentially. I mean, you could use it to hold books up if you didn't know how to use it, the computer - but with appropriate knowledge and skills it serves a function. Therefore, the knowledge and skills become a part of the technology as much as does the inanimate objects that we use. And then broader to that, I would see, just in terms of say looking at health care, the way in which our knowledge and skills develop in relation to the various sort of resources and tools and so forth that we use, they're within organisational, political and economic frameworks. So they too become pulled into the … so the decision-making about using various forms of IT in say a hospital are as much about purchasing a computer from … Coretech, as it is about developing the knowledge and skills to use them, as it is about the economics and politics associated with their purchase, use and continuing application. Therefore, the … paper on processing architecture is as much IT research as is the one looking at social implications. (11.3a)*

> *When we think of information technology, what is it? It's a hybrid. It has to be able to cater for this convergence of technologies, I guess that's the ultimate deliverable. So we do have computer science offering up a tremendous amount of theory and practice. We have data communications and networks and internetworking, which is new, now being added to that particular fold. And we have IS and its expanding elements of seeing a system as a social system as also having legitimacy within the umbrella of information technology. (15.4b)*

In this way of seeing, the application of IT in particular fields such as business, medicine and education is included as valid IT research. In contrast to limiting the application of technology to purely technological problems, which may be acceptable in Category 1, this category expands the scope of application to include application of technology to disciplines which may otherwise not be associated with technology.

> *[When you look at these projects and try to decide where they fit, what helps you take that decision?]*
> *Well, … the educational one because we're applying [it] … to information technology teaching and I would consider that clearly is an information technology research ... although it could be done in the education department but they would be information technology educationalists that would be doing that … (1.3a)*

> *I regard implementing something as a part of IT research, or, let's say, a part of IT. (5.3)*

> *Could it fit under business or marketing or economics … education? (pause) IT services all those disciplines – it's not under any one umbrella. (11.5c)*
>
> *… there is probably very little pure IT research … applied research. It would seem to me that the bulk of IT research, to honour its own rationale, is being applied in human, business, medical or other contexts. (17.4a)*

To some participants in this category, application is the defining element of IT research and helps delineate it from other types of research.

> *[It would be excluded from IT] … if there was no … likely application, perhaps one could go even stronger and if there was no obvious application … (2.6a)*
>
> *I wouldn't say that if you're working in cognitive science, I wouldn't say you're doing IT research until you try and apply it. (10.5d)*
>
> *[And what, in that context, would be the IT part of research?]*
> *The IT would be the solution-finding part, that the application phase is almost being agendised in advance. (17.5c)*

Another point of departure from IT in this category is when technology is not referred to at all.

> *If they deal with hardware, with software, with software development, with implementing something on a computer. … As soon as we use computers - hardware/software - I think this is IT, this is part of IT, that should be of interest for researchers. So, I was really scanning … these abstracts and said, "Do they do something with a computer?", "Do they use a computer for their work?", and then in the second step, you can differentiate, "Is it completely embedded in IT?" - where they talk about reuse of software or where they are interested about how does the usage of a computer influence a BPR project, where, say, it's more related IT. … If it would be completely about an accounting problem, about a biological problem, without any mentioning of something that I would see as a part of IT – hardware/software computer development – I would say it's not IT. (5.6d)*

10.5.1.1 Information

Information in this category is interpreted by the participants as encompassing the full range of sophistication, from manipulating data to teaching and managing. It seems to be assumed that information transfer is occurring whenever humans are engaged with technology.

> *… you could loosely classify all of them in … the area of IT research. I think they sort of represent the same way that our centre represents … that the research we do in our centre covers a very, very wide area of information technology research. We cover from the hard-core technology which is the cryptology, the network security, to … areas which have to do with policy … looking at the risk involved in using information security systems … and including legal issues in that of information security … (1.1d)*

10.5.1.2 Technology

Technology in this category is interpreted by the participants as being computer hardware and software.

> *If they deal with hardware, with software, with software development, with implementing something on a computer. … As soon as we use computers - hardware/software - I think this is IT, this is part of IT, that should be of interest for researchers. (5.6d)*

10.5.2 The research object

The focus of IT researchers in this category, their research object, is Technology used in any Application, this being defined here as 'Ubiquitous'. This may be represented as follows:

T+Application (Technology and Application = Ubiquitous)

The object of research is the development, maintenance, use of and impact of computers in any setting.

> *[… so, what would stop it from being IT … as in, falling within the realms of IT research?]*
> *… from what I can see, I don't think that you could ever draw that boundary. The boundaries of IT are just so fuzzy - it permeates everything. (3.7d)*

10.5.3 Constituting the territory

The territory of research in this category expands to include all endeavours that use computers.

This view is boundless and represents the broadest possible perspective of what is included in IT research. People who see this way consider application of technology to be the essential component of IT research and thus the integral element in defining the character of the field.

With the existing pervasiveness of the use of computers, this way of seeing is considered to reflect the present state of play in the evolution of IT as a discipline.

Categories 6 to 8 represent a completely different approach to IT research.

10.6 Category 6: The Sanctioned Conception

10.6.1 Meaning

In this category what constitutes IT research is seen as being determined by others. That is, IT research is seen as that which is sanctioned by others as IT research.

Researchers who see IT research in this way consider the opinion of people other than themselves as central in defining IT. This opinion may be expressed in what is acknowledged as being part of established IT Faculties, or in the acceptance of papers at IT conferences. It may also be the researcher's understanding of society's view of IT.

Researchers see the research community as being in an active relationship with IT research, determining its definition. Individual researchers, however, do not see themselves as influencing that definition.

> *… to some extent I guess it's just the status quo isn't it? Because we're there and then nobody else has proven that we shouldn't be there … we continue to do it. … people don't really question … this doesn't belong here or it doesn't belong there. So, creating the boundaries doesn't seem to be something that we tend to do - not that I've seen, anyway. (3.6a)*
>
> *… there is a computing science school in the Faculty of Information Technology, so I think computing science is acknowledged as a discipline of information technology. (7.1c)*
>
> *This has to do with the central area of software reusability, software development, it would have to be seen as a core element of information technology. … Because information technology is about developing systems and this is one of the focal points, whether you find it within schools of information systems and schools of computing science - a very, very important research and practical problem. And everybody within the continuum of IT should see that one as IT research. (15.6b)*

10.6.1.1 Information

Information in this category is interpreted by the participants as encompassing the full range of sophistication, from data manipulation to knowledge management.

> *When I was doing work in knowledge engineering, basically trying to come up with a framework for extracting knowledge from experts … I knew that that was computer science research because that was the domain that it was found in … (15.2b)*

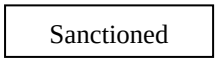
10.6.1.2 Technology

The approach to technology is not clearly enunciated by the participants articulating this way of seeing but seems to be interpreted as the hardware and software of computers. Areas mentioned in the context of this way of seeing include how computers learn, artificial intelligence, computing science, system development, software creation and computer graphics.

10.6.2 The research object

The focus of IT researchers in this category, their research object, is not clear. However, the object will be IT research if it is sanctioned. The focus of IT researchers in this category, their research object, appears to be issues that are sanctioned by others.

This may be represented as follows:



> *… computer graphics tends to be mathematics. I would see that this would certainly sit within the computer graphics side of computer science, however, so there would be a number of people who would say that this is central to those sorts of things and as a result it would be viable as information technology. (15.6b)*

10.6.3 Constituting the territory

The territory of research in this category is delimited by other people's perceptions of IT research. It is other people's perceptions which define the essential character of the field.

In this view, deference is paid to the sanctioned opinions of others. This contrasts with the following categories in which a greater level of personal responsibility is accepted for how IT is defined.

10.7 Category 7: The Dialectic Conception

10.7.1 Meaning

In this category what constitutes IT research is seen as being determined as a dialectic between the individual researcher's goals and sanctioned views.

Researchers who see IT research in this way consider both established views of IT research and their own goals in classifying research as being central in determining how IT is defined. An individual's purpose in choosing to classify their research as IT may relate to winning funding from a specific panel, being accepted for publication in an established journal, positioning themselves to advance their knowledge, or conformity to regulations of an esteemed university. In this category, if an IT researcher classifies their research as IT, it is generally done in order to gain some kind of advantage.

> *[In general, how do you decide whether a particular research project is IT research or not?]*
> *It depends who's giving me money for it, I guess. (14.4b)*

> *[Is your research IT research?]*
> *I think it's at the cross-road between computing science, mathematics, engineering and … yeah, I don't care about the label, as long as I have some time to do this research. (7.1b)*

In this category, researchers are in a dialectic relationship with IT research. That is to say, they are influenced by sanctioned definitions of IT research but they are also influencing the definition of IT research. The researcher is interacting with existing classifications of IT research, to some extent trying to fit into them and to some extent trying to change them.

From one point of view, researchers are relating passively to research classification, as they perceive it to already exist. In order to acquire financial support, they may submit to an IT funding panel a project which has up to that point in time not been clearly defined as IT research. In the course of writing their

proposal, they emphasise elements of the project that have already been accepted as falling within the realm of IT research and in this way are being influenced by existing definitions of the field. For example, a business application may be reported according IT specifications if this benefits the researcher (by making them more likely to successfully receive funding from an IT committee). Therefore, researchers in this category do not see themselves as having an unlimited effect on the way research is classified or see themselves as being in an unconstrained position to change it, rather they see themselves as conforming to the existing definition or working within it.

> *… it would be possible to take the same piece of work and you … reword it or sell it in a different way to make it IT or business … (16.4b)*

On the other hand, these researchers are hoping the definition of IT research is open to change and therefore able to embrace their project proposal. If the response of the funding committee is positive, then the applicants have influenced the committee to conclude that the project is IT research and they have therefore helped broaden the definition of IT research. If the response of the committee is negative, the applicants have helped the committee draw a clearer boundary between research that belongs to IT and research that does not belong to IT. The researchers are thus actively pushing the boundaries and influencing how IT research is being defined.

> *Now, you can't separate the classification and categorisation from an end purpose. So, is the work I do IT research? Well yes, because I might deliberately define it that way, because my end objective is to move research applications which I put in to a different assessment committee, for argument's sake. This is very important. Therefore, in human classification and categorisation systems … we really have an end purpose in mind. (4.3a)*

This dialectic relationship was extended by one participant to an interaction between IT researchers, practical research outcomes and industry demand.

> *… although you can regard them [computers] just as being some kind of calculating engine … they actually have a practical use and that's what tends to ... drive a lot of IT, and obviously there has been some interesting developments in terms of the way that sometimes people in IT research have … driven IT compared with then … the practical and industry and business-based ramifications of what happened because people need to use IT to get things done … there are advances that are being made in terms of hardware and networking and things like that, and that's …enabling new things to happen in terms of IT. Things like the World Wide Web and just the amount of money and business implications of manufacturing things and the size of markets … tends to effect … the nuts and bolts that we have and what we can do with them. In universities often we tend to think about things … in a sort of pure sense … That then has to be ... balanced with the needs of industry and pushing ahead on what can actually be sold, if you like. So, there are … tensions there … (16.3c)*

10.7.1.1 Information

Information is not clearly enough described by the participants articulating this way of seeing to know how it is being interpreted in the context of this category.

10.7.1.2 Technology

Technology is not clearly enough described by the participants articulating this way of seeing to know how it is being interpreted in the context of this category.

10.7.2 The research object

The focus of IT researchers in this category, their research object, is unclear. However, the object will be IT research if it satisfies both the researcher's goals and established IT research institutions which will allow them to pursue those goals. The focus of IT researchers in this category, their research object, appears to be issues that are both sanctioned by others and personally constructed.

This may be represented as follows:

Dialectic

> *… it's not just our opinion, of course … we don't look at this as a problem in a vacuum – we are swayed enormously by … where you can get published and where you can get grants … You either conform or rebel or try and modify or agree with or whatever, but you can't ignore what the majority or even the dominant paradigm is. (10.7c)*

10.7.3 Constituting the territory

The territory is being constructed with respect to the relationship between the goals of the individual researcher and the recognised definition of IT research.

The territory of research in this category is delimited by the purposes of the individual researcher in relationship with the views of others. Thus, it is the interaction between the purposes of the individual researcher and the sanctioned views of others which define the character and structure of the field.

This view is an intermediary position between the preceding and following categories. It contrasts with the preceding category in that researchers perceive in this category that they can have some influence over existing structures. It contrasts with the following category in that individual researchers in this category still see themselves as fitting to some extent within existing structures, as others define them.

10.8 Category 8: The Constructed Conception

10.8.1 Meaning

Fragments of this category were found, there are only a few indications of its existence.

In this category what constitutes IT research is seen as being defined, or constructed, by the IT research community.

Researchers who see IT in this way see themselves as actively constructing the territory of IT research. That is to say, they are in the process of defining the character of IT research. In their interactions with each other and the outside world they see themselves and their colleagues as participating in the process of dynamically forming the territory of research. IT researchers in this category would perceive themselves as definers, innovators, explorers and change agents. They are looking for ways in which they are distinct and different from the rest of the world. Researchers see themselves as being in an active relationship with IT research.

> *I suppose IT being new, so new, what – 50 years? … maybe less, it wants to say what is it … because it's very important to define yourself away from the other people, so that you can say, "Well, that's not IT and IT is important, so give us the money." (12.10d)*

> *… I mean, it is important I guess for IT, it is important that you have a feeling of your identity so that you don't spread yourself everywhere … I guess that makes it important, that you know what your corpus is, what your central – what do you bring to the world that's different from the rest of us? (12.11b)*

10.8.1.1 Information

Information is not clearly enough described by the participants articulating this way of seeing to know how it is being interpreted in the context of this category.

10.8.1.2 Technology

Technology is not clearly enough described by the participants articulating this way of seeing to know how it is being interpreted in the context of this category.

10.8.2 The research object

The focus of IT researchers in this category, their research object, is not clear. However, the object will be IT research if it is the result of their active construction of the IT research territory. The focus of IT researchers in this category, their research object, appears to be issues that are personally constructed.

This may be represented as follows:

Constructed

10.8.3 Constituting the territory

In this category it is the researcher themselves who chooses what lies within the realms of IT research and what is excluded from it. The researchers have a clear idea in this category as to what their contribution is. They have an active role in the continuing evolution of the field.

> *I was trying to get at what the authors were stating their contribution was. (16.4b)*

The territory of research in this category is limited only by the perspectives of IT researchers. It is the IT researcher who is in the process of defining the character of the field.

In this category, others' opinions are subject to the judgement of the individual researcher.

> *… it would be seen by some as being certainly on the cognitive side of computer science and therefore belonging to the field of IT but to me its approach is mathematics. (15.5c)*

This view sees the researcher as being in control of and responsible for what is included in IT research.

11 Discussion

This project was supported by a QUT ATN Small Grant, the Centre for Information Technology Innovation and the Research Office of QUT's Faculty of Information Technology. QUT's Centre for Information Technology Innovation is the location of a significant group of information technology researchers in Queensland. The current analysis provides a picture of ways of seeing IT research, its objects and territories, amongst a particular community of IT researchers.

11.1 Relationship of categories to history of IT research and previous phenomenographic studies

There would seem to be a connection between the history of the development of IT and the history of the development of IT research. This is possibly caused by the increasing link in IT between industry and research. With reference to the historical development of IT as outlined in Section 2, the link between Category 1 (Technology) and technological development through to the early 20th century is clear, as is the link between Category 5 (Ubiquitous) and the more recent convergence of technologies. The intermediary steps are not as obvious and would require further study in order to establish the veracity of our hypothesis.

A potential link between Brew's study of researchers' conceptions of research (Brew 2001) and ours appears to be possible. However, a review of her work seems to have revealed little overlap. This is probably because the current project looked at views of a research object in a discipline-specific context whereas Brew's research spanned a breadth of disciplines and was focussed on conceptions of research but not on specific research objects. Further analysis is needed to determine the accuracy of these observations.

11.2 Potential use of these results

Outcomes of this project could be useful at both the Faculty and University levels for development of strategic directions, to facilitate collaboration with researchers from other disciplines and industry, and to establish cooperation between faculty based research groups, and in researcher education and training. The project, which is part of a new global research direction that is in its earliest stages, will act as a feasibility study for a larger inquiry that will add breadth and depth to the investigation. The

project also serves as a precursor to a wider investigation of the different ways in which information technology researchers from different sub-disciplines construct their research domain.

11.3 Recommendations for further research

This research has captured the views of a particular community at a particular point in time. Further research is needed to provide a point of comparison with the findings of this research and to help ascertain how generalisable the conclusions are.

Moreover, the current research has not attempted to differentiate between the views of sub-disciplines within the research community. A study of sub-disciplines holding potentially diverse points of view, for example computer science and information systems, may contribute to the research community's understanding of how variation in conception influences significant aspects of the research process and culture. Research into variation in IT researcher sub-discipline views could investigate the impact of variation on such aspects as the development of research projects in terms of their methodologies; the evaluation and assessment of research results; and perceptions of the usefulness, economic value and significance of research.

Also, since IT research is presently in a highly creative position and the research territory is in the early stages of formation, there is likely to be ongoing discussion and debate about what avenues should be followed and which approaches should be adopted. These are all based on different ways of seeing the territory, and different ways of attending to the object of research. Accepting these differences as complementary will provide the basis for continued expansion and construction of the territory, and will lay a foundation for individuals and groups with different perspectives to begin to work together on critical questions, problems and issues. What will be investigated, and possibly what will not be investigated, will inevitably result from the interplay of the values and world views of the researchers, and the politics of the investigations. It is proposed that if researchers from non-IT disciplines see IT research (its objects and territories) as falling within Category 1, they are likely to see IT researchers as resources of their work, rather than partners. This was evidenced during the current research:

> *I guess with my mathematics background I'd say I wouldn't need anybody to help me do all that stuff. But I guess if it had … if there was a component of it that improved the tools, then I would probably say then we need to bring in an IT person … to improve – if you think of IT as a tool – improve the tools … and you needed that particular information. I can say generally, "I want a tool … that will allow Powerpoint to cut in half and split", but I'd give that to an IT person to do the programming … and to determine how that's best done and … whether I was even using the right software … (12.11d)*

Similarly, if IT researchers see their research as falling within Category 1 they are less likely to start to build partnerships. It seems that changes in ways of seeing the object of research result in changes in ways of seeing the territory. Therefore, if you want to change the way people see the territory, you have to attend to the way they see the object. This is another suggested object of further investigation.

11.4 Observations

11.4.1 Evidence of reflective thought

A number of participants expressed the fact that they were being asked to think about this topic in depth for the first time. Many said that normally they do not reflect on the definition of IT research at all.

> *I've never questioned that they weren't part of information technology. (3.4c)*

> *… the links I think I've already got in my head … "Well, if it comes within this area then, historically that has been a part of IT, or we have done research in that area in IT" and so therefore one perhaps assumes that there's no reason why it shouldn't be. … it's never been questioned that that would be part of IT so therefore … maybe that's just echoing the status quo, rather than being … I don't know that I've ever seen any objective look at this. (3.5d)*

> *… creating the boundaries doesn't seem to be something that we tend to do … (3.6c)*
>
> *… the fact that it's here, and how it got here and so forth is I don't think important. To me it's success driven rather than ideology. (3.6d)*
>
> *I don't think anybody has ever – from what I have seen - I don't think that question ever genuinely gets asked - you know, "Should we be doing this at all?" … From what I've observed over a period of time, that doesn't seem to be the criteria for success or failure. Things stop happening, I mean people stop doing work in certain areas simply because they don't meet the criteria – they don't get money, they don't get enough interest, they don't get the publications – so they move and do something else. (3.7a)*
>
> *I do not necessarily ask myself continuously and always, "Is it IT research?" (5.1c)*
>
> *I don't have a reason to think about something and say, "Is this IT or isn't it IT?" If it's research that's relevant for me, then I'm interested in it - I don't care if it's IT or not. (9.4c)*

In the course of the interview, the participants' responses often indicated that they were in the process of discovering their own thoughts.

> *… it's interesting isn't it what you discover when you're asked to talk about things?! (9.3a)*
>
> *… so it's the interaction between what's going on in the mind of the person and the information that's being presented by the technology. (pause) I just made that up. (9.5c)*
>
> *It's interesting to see what one finds in one's brain when one talks about these things! (9.5d)*
>
> *I hadn't thought about it very much until I started talking to you. (10.9c)*
>
> *Well, I suppose information technology … is … to give you a definition, I suppose it's an effective use … my definition of information technology … (pause) it involves the … I don't know … the constructive and critical use of information that is enhanced by the use of efficient technology, something like that. (13.6c)*

As part of this process, the participants sometimes fluctuated between various (even seemingly contradictory) ways of seeing.

> *OK, we've changed our mind then after that discussion. I've never thought of that … (12.10c)*
>
> *[Now, you started off by saying quite clearly that you are not an IT researcher but you've just given an example from your own research …]*
> *Yes … I suppose, yes, ok - there's some learning and some development there! (13.7c)*

This illustrates one aspect of the value of the semi-structured interview, in that it captures the process of the development of thoughts on an issue, and allows the interviewee to express their doubts as well as their certainties in a fuller way than some other methodologies.

11.4.2 The influence of culture

Some of the participants acknowledged the influence culture has over a researcher's perspective of IT.

> *I believe there is a very, very big difference between the way Australians classify and categorise information technology research to what's done in other countries, specifically those who have an IT industry itself - an information artefact industry itself. (4.9c)*

The nature of the IT industry in the researcher's country of origin is seen to influence how they approach IT.

> *I've found in other places, where society has become essentially totally dependent upon a foreign technology, over which they have no control, which they, in many cases, have*

> *no access to, then it becomes – the classifications tend to become more mystic. They actually become quite arbitrary. This is my kind of feeling. (4.10a)*
>
> *Could a graduate in Computer-ing Science … make a computer tomorrow? … I would say, right now, the answer is they couldn't. This is very interesting. In the 70's, they could. Interesting isn't it? So, we're now talking about classification and categorisations that actually change not only on the nature of the society in which we live – Australia being a consumer of IT artefacts, we use IT artefacts, we don't create the IT artefacts. This is very interesting. We may even have knowledge … of information technology but there's one other thing I haven't told you about. Go back to the axe thing. I may know how to … make a stone axe - but if I haven't got the right lumps of stone, I'm stuck. Same thing applies with IT. I may know how, in principle, a computer works, but I've got no chip factory, so I can't make the chips, for argument's sake. So, you're limited by the environment. Then you're limited by essentially a societal image. So IT basically is mystic in this country. … no one knows what's inside a Pentium chip ... So, it becomes almost literally a deity. It becomes an unknown, mystic quantity … that then limits the way in which it is classified and categorised. (4.10d)*

The definitions of IT in other cultures differ amongst experts in the field, thus influencing individual researchers' views.

> *… in Germany we see Information Systems – we call it "Workschaft Informatik" and a one-to-one translation would be "Business Informatics", or something like this, but we accept the term Information Systems and big conferences for us are conferences on Information Systems. So, I am extremely influenced by this German understanding of how they see the IS/IT community, and here we use the term 'Computer Science' and 'Information Systems' and there's no mentioning of IT. They are both dealing with IT, we would say, but we would see IT as more the domain. Information systems is the discipline, but our domain is IT. In Computer Science it's only IT and in Information Systems is IT and its application in business contexts. My answer, "IS as a subset of IT", is now strongly influenced by, let's say, the Australian understanding where many faculties for IT exist and typically schools and departments or so for IS exist. (5.4d)*

An international study of perspectives on IT may reveal more ways of seeing IT research and thus reveal additional potential causes for conflict, or creative tension, in the field.

11.5 Conclusions

IT researchers are only just beginning to develop a collective consciousness, a consciousness which represents the emerging research territory. Clearly, the territory is expanding and we do not know what constitutes the unexplored areas until we start moving out into those spaces. The IT research territory does not exist, however, separately from the work of researchers and others interested in it. We, through our human acts, construct that territory and allow it to emerge in our collective consciousness. As that collective consciousness grows, and we begin to better understand each others' ways of looking at and working within the territories of IT research, our understanding of information technology as a unique phenomenon should also grow. Essentially, all contributors to the research collective are exploring different parts of the whole, or approaching the phenomenon in unique ways, which lead to particular kinds of contributions.

12 References

Baillie, C., Emanuellson, J. and Marton, F. (2001). Building knowledge about the interface. *Composites Part A: Applied Science and Manufacturing 32* (3-4), 305-312.

Bowden, J. and Marton, F. (1998). *The University of Learning: beyond quality and competence in higher education.* London: Kogan Page.

Bowden, J. (1995). Phenomenographic research: some methodological issues. *Nordisk Pedagogik 15* (3), 144-155.

Brew, A. (2001). Conceptions of research: a phenomenographic study. *Studies in Higher Education 26* (3), 271-285.

Bruce, C., B. Pham and I. Stoodley. (2002a). *The collective consciousness of information technology research. The significance and value of research projects. A. The views of IT researchers.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Res.pdf.

Bruce, C., B. Pham and I. Stoodley. (2002b). *The collective consciousness of information technology research. The significance and value of research projects. B. The views of IT industry professionals.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Ind.pdf.

Bruce, C., B. Pham and I. Stoodley. (2002c). Constituting the significance and value of research projects: Views from the information technology research community. (in progress) Proposed for submission to *Studies in Higher Education*.

Bruce, C. and Pham, B. (2001, July). Investigating ways of seeing IT research: a tool for facilitating effective research partnerships? In *Learning Partnerships.* Proceedings of the 24th International HERDSA Conference, Newcastle, University of Newcastle, Australia: HERDSA. [CD-ROM]

Bruce, C. S. (1994). Reflections on the experience of the phenomenographic interview. In Roy Ballantyne and Christine Bruce (Eds), *Phenomenography, Philosophy and Practice,* 47-56. Brisbane: Centre for Applied Environmental and Social Education Research, QUT.

Gerber, R. (1993). A sense of quality – qualitative research approaches for geographical education. In H. Jager (Ed.), *Liber Amicorum Prof Niemz,* Frankfurt am Main: Goethe University Press.

Goldsworthy, A.W. (1997). *The global information economy: the way ahead.* [Canberra] : The Information Industries Taskforce.

Hall, P. & Preston, P. (1988) *The carrier wave: New information technology and the geography of innovation 1846-2003*. London: Unwin Hyman Ltd.

Kiley, M. (2000). *Students' conceptions of research.* Website. Retrieved 25 September 2002 from http://www.canberra.edu.au/celts/scor/conf_pres.html.

Marton, F. (1994). Phenomenography. In T. Husén & T. N. Postlethwaite (Eds.), *The International Encyclopedia of Education.* (2nd ed.), vol. 8, 4424 - 4429. Pergamon. Retrieved 22 May 2001, from http://www.ped.gu.se/biorn/phgraph/civil/main/1res.appr.html

Marton, F. and Booth S. (1997). *Learning and awareness.* London: Lawrence Erlbaum

The New Britannica Encyclopaedia: Macropaedia. (1998) 15th Edition. Chicago: Encyclopaedia Britannica Inc.

Pham, B., Bruce, C. and Stoodley, I. (2002). *Understanding and influencing a learning community,* presented at Lifelong Learning Conference, Yeppoon, June 2002.

Preston, P. (2001). *Reshaping communications: technology, information and social change*. Sage: London.

Saljo, R. (1988). Learning in educational settings: methods of enquiry. In *Improving Learning: New Perspectives*, Paul Ramsden (Ed.). London: Kogan Page.

Sandberg, J. (1994). *Human competence at work.* Goteborg: Bas.

Sandberg, J. (1995a). How do we justify knowledge produced by interpretative approaches? In *EFI Research Report,* Stockholm School of Economics, The Economic Research Institute.

Sandberg, J. (1995b). Are phenomenographic results reliable? In *Nordisk Pedagogik 15* (3), 156-164.

Sandberg, J. (2000) Competence - the basis for a smart workforce. In R. Gerber and C. Lankshear (Eds.) *Training for a smart workforce*. London: Routledge.

Sara, V. (1998). *Information Technology, Sink or Swim*. (Australian Academy of Technological Sciences and Engineering, Australian Research Council). Canberra: AusInfo.

13 Bibliography

AVCC. (1996). Exploiting information technology in higher education: an issue paper. Retrieved from http://www.avcc.edu.au/avcc/pubs/eitihe.htm

Baillie, C., Emanuellson, J. and Marton, F. (2001). Building knowledge about the interface. *Composites Part A: Applied Science and Manufacturing 32* (3-4), 305-312.

Batterham, R. (2000). *The Chance of Change*. Department Industry Science Resources, Commonwealth of Australia. Canberra: AusInfo.

Booth, S. (1992). Learning to program: a phenomenographic perspective. *Acta Universitatis Gothoburgensis*, Goteborg.

Bowden, J. & Marton, F. (1998). *The university of learning: beyond quality and competence in higher education*. London: Kogan Page.

Bowden, J. & Walsh, E. [Eds] (2000). *Phenomenography*. Melbourne: RMIT University Press.

Bowden, J. (1995). Phenomenographic research: some methodological issues. *Nordisk Pedagogik 15* (3), 144-155.

Brew, A. (1998) Understanding research: exploring different conceptions. In J. Higgs and R. Cart [Eds.] *Writing qualitative research*. (pp. 9-20). Sydney: Hampton Press.

Brew, A. (2001). Conceptions of research: a phenomenographic study. *Studies in Higher Education 26* (3), 271-285.

Bruce, C. S. (1994). Reflections on the experience of the phenomenographic interview. In Roy Ballantyne and Christine Bruce (Eds), *Phenomenography, Philosophy and Practice*, 47-56. Brisbane: Centre for Applied Environmental and Social Education Research, QUT.

Bruce, C. (1994). Research students' early experiences of the dissertation literature review. *Studies in Higher Education 19* (2), 217-229.

Bruce, C. (1997). *Seven Faces of Information Literacy*. Adelaide:Auslib Press.

Bruce, C. (1999). Phenomenography: opening a new territory for LIS research. *New Review of Information and Library Research 5*, 31-48.

Bruce, C. (2000). Information literacy research: dimensions of an emerging collective consciousness. *Australian Academic and Research Libraries 31* (2), 91-109.

Bruce, C. and Pham, B. (2001, July). Investigating ways of seeing IT research: a tool for facilitating effective research partnerships? In *Learning Partnerships*. Proceedings of the 24th International HERDSA Conference, Newcastle, University of Newcastle, Australia: HERDSA. [CD-ROM]

Bruce, C., B. Pham and I. Stoodley. (2002). *The collective consciousness of information technology research. The significance and value of research projects. A. The views of IT researchers.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Res.pdf.

Bruce, C., B. Pham and I. Stoodley. (2002). *The collective consciousness of information technology research. The significance and value of research projects. B. The views of IT industry professionals.* FIT Technical Reports. QUT. May be retrieved from http://sky.fit.qut.edu.au/~bruce/pub/FRep-Ind.pdf.

Bruce, K. (1996). Thoughts on computer science education. *ACM Computing Surveys 28* (4). Retrieved from http://www.acm.org/surveys/1996/Formatting/

Cope, C., Horan, P. and Garner, M. (1997). Conceptions of an information system and their use in teaching about IS. *Informing Science 1* (1), 9-22.

Dall'Alba, G. and Sandberg, J. (1996). Educating for competence in professional practice. *Instructional Science 24*, 411-437.

Fitzgerald B. and Howcroft D. (1998). Towards dissolution of the IS research debate: from polarisation to polarity. *Journal of Information Technology 13* (4), 313-327.

Gerber, R. (1993). A sense of quality – qualitative research approaches for geographical education. In H. Jager (Ed.), *Liber Amicorum Prof Niemz*, Frankfurt am Main: Goethe University Press.

Gerber, R., Buzer, S., Worth, C. and Bruce, C. (1992). Is GIS a GIS? Or coming to an experiential understanding of GIS. In Gerber, R. (Ed) *AURISA 92. Power to the People: the Community, Information and Management*, Proceedings of the Twentieth Annual International Conference of the Australasian Urban and Regional Information Systems Incorporated (pp.18-24). AURISA.

Glazier, J. and Powell, R. (eds) (1992). *Qualitative research in information management.* Englewood : Libraries Unlimited.

Goldsworthy, A.W. (1997). *The global information economy: the way ahead.* [Canberra] : The Information Industries Taskforce.

Harman, G. (2001). Industry-research partnerships in Australia: extent, benefits and risks. *Higher Education Research and Development 20* (3), 245-264.

Hirscheim, R., Klein, H. and Lyytinene, K (1996) Exploring the intellectual structures of information systems development. *Accounting, Management and Information Technology 6* (1/2), 1-64.

Jacob, M. & Hellstrom, T. (Eds.) (2000). *The future of knowledge production in the academy.* Buckingham, England: Society for Research into Higher Education and Open University Press.

Kemp, D.A. (1999). *Knowledge and Innovation: A policy statement on research and research training*. (Department of Education, Training and Youth Affairs, DETYA, No 6425) Canberra: AusInfo.

Kiley, M. (2000). *Students' conceptions of research.* Website. Retrieved 25 September 2002 from http://www.canberra.edu.au/celts/scor/conf_pres.html.

Klaus, H. and Gable, G. (2000). *Senior managers understandings of knowledge management in the context of enterprise systems.* 6th Americas Conference on Information Systems, Long Beach, California, August 10th - 13th, 2000: 981-987

Lincoln, Y.S. and Guba, E.G. (1985). *Naturalistic Inquiry*. Beverly Hills: Sage.

Marton, F. (1994). Phenomenography. In T. Husén & T. N. Postlethwaite (Eds.), *The International Encyclopedia of Education*. (2nd ed.), vol. 8, 4424 - 4429. Pergamon. Retrieved 22 May 2001, from http://www.ped.gu.se/biorn/phgraph/civil/main/1res.appr.html

Marton, F. (2000). The structure of awareness. In J. Bowden and E. Walsh (Eds.) *Phenomenography*. Melbourne: RMIT University Press.

Marton, F. and Booth, S. (1997). *Learning and awareness*. Mahwah, New Jersey: Lawrence Erlbaum.

Pham, B. (1997). The changing curriculum of computing and information technology. In *Proceedings of the Second Australasian Conference on Computer Science Education*, July 1997 Melbourne, 149-154.

Pham, B. (2000). Research at regional universities in Australia: visions and realisation, *Higher Education Management 12* (2), 117-130.

Pham, B., Bruce, C. and Stoodley, I. (2002). *Understanding and influencing a learning community*, presented at Lifelong Learning Conference, Yeppoon, June 2002.

Phenomenography – Terminology. (1996). Retrieved 22 May 2001, from http://www.ped.gu.se/biorn/phgraph/civil/main/firstidea.html

Quarantelli, E. L. (1997). Problematic aspects of the information/communication revolution for disaster planning and disaster research: ten non-technical issues and questions. *Disaster Prevention and Management 6* (2), 94 –107.

Roche, E.M. (1996). Multinational corporations - the merging research agenda (information technology). In *The Journal of Strategic Information Systems 5* (2), 129-148.

Sahay S. (1997). Implementation of information technology: a time-space perspective. *Organization Studies 18* (2), 229- 261.

Saljo, R. (1988). Learning in educational settings: methods of enquiry. In *Improving Learning: New Perspectives*, Paul Ramsden (Ed.). London: Kogan Page.

Sandberg, J. (1994). *Human Competence at Work*. Goteborg, Bas.

Sandberg, J. (1995a). How do we justify knowledge produced by interpretative approaches? In *EFI Research Report*, Stockholm School of Economics, The Economic Research Institute.

Sandberg, J. (1995b). Are phenomenographic results reliable? In *Nordisk Pedagogik 15* (3), 156-164.

Sandberg, J. (2000) Competence - the basis for a smart workforce. In R. Gerber and C. Lankshear (Eds.) *Training for a smart workforce*. London: Routledge.

Sara, V. (1998). *Information Technology, Sink or Swim*. (Australian Academy of Technological Sciences and Engineering, Australian Research Council). Canberra: AusInfo.

Simon, H.A. (1999). Information technology research. In *Science 285* (5435), 1849.

Stewart, G. and Klaus, H (2000). *Characterising the Business-IT Executive Relationship*. 6th Americas Conference on Information Systems, Long Beach, California, August 10th - 13th, 2000:1913-1918

Williams, R. and Edge, D. (1996). The social shaping of technology. In *Research Policy 25* (6), 865 – 900.

Williamson, K. (1999). *Research methods for students and professional: Information management and systems*. Wagga Wagga: Centre for Information Studies, Charles Sturt University.

Winder, R., Probert, S. and Beeson, L. (eds) (1997). *Philosophical aspects of information systems*. London: Taylor & Francis.

14 Appendices

The following documents are attached:

14.1 Ethical clearance from the QUT Office of Research

14.2 Letter of invitation to participate in the project

14.3 Consent form signed by each participant before their interview

14.4 Profile form filled out by each participant before their interview

14.5 Abstracts used to stimulate discussion during the interviews

Subject: Re: please print letter, and send to Ethics Committee
To: Christine Bruce <c.bruce@qut.edu.au>

Christine

I write in relation to your request for a minor modification to your project / clearance, "Information Technology Research: Dimensions of the Collective Consciousness (ways of seeing IT research, its objects and territories.)" (QUT Ref No 2050).

Your request has been considered by the Deputy Chairperson of University Human Research Ethics Committee and he has asked me to contact you on his behalf. The Deputy Chairperson has approved your requested changes to this project, consequently the title of the project / clearance has been changed (as per the above) and the requested changes to the testing instrument have been approved.

Please note, such changes to a project which has been previously confirmed exempt (rather than awarded ethical clearance) do not require the prior approval of the Committee. However, in light of the need for your to demonstrate you have appropriate ethical authorisation for this work for grant purposes, it was considered appropriate to submit these changes for approval. Any future changes (to this, or any other project which has been confirmed exempt) need only be submitted for approval if they raise new or additional ethical issues. Any change to a project which has been awarded full or expedited ethical clearance must receive prior approval.

Please do not hesitate to contact me if you have any further queries in relation to this matter.

Regards

Gary Allen
Secretary, UHREC
x2902

At 10/01/01, you wrote:

> Hi Trudi - or whoever is there (Happy New Year) Pleae print this on letter head for me - thanks Christine
>
> Gary Allen
> The Secretary, University Human Research Ethics Committee
>
> Re: Experienced Variation of the IT Research Domain: a phenomenographic investigation Ref No: 2050H
>
> An ATN Small Grant has been approved to take forward the above project, cleared by the Ethics Committee in October 2000. Grant ID 20000442
>
> We now request a change to the title of the project as follows : Information Technology Research: Dimensions of the Collective Consciousness (ways of seeing IT research, its

Ways of seeing Information Technology Research

Funded through the QUT ATN Small Research Grants Scheme

Dr Christine Bruce and Prof. Binh Pham
Faculty of Information Technology

invite you

to participate in an investigation of our collective understanding of information technology research. In this study we are particularly interested in how we, as IT researchers, see **what constitutes IT research**.

We believe that variation in our ways of seeing IT research is essential to the **development of our field**; and that understanding this variation will **facilitate greater collaboration** with researchers from other disciplines and industry and **establish cooperation** between faculty-based research groups.

We hope you will be able to find time to participate in an **interview** (30-45 minutes in length). The purpose of the interview will be to discover how you decide whether particular studies are indeed IT research or not.

Interviews will be taped and transcribed. We will not be attempting to correlate research outcomes with the various IT sub-disciplines. Also, individuals will not be identifiable from the data extracted for use in reporting the research outcomes. All responses will be treated **confidentially**, and will be separated from the names of their authors at the earliest possible stage in the research process.

We hope you will be able to participate in this project. We have approached you as a participant because you are a research grant holder, or have been a research grant holder in recent years. You will be contacted by Ian Stoodley in the near future to receive your response and hopefully arrange an interview time.

Please note that participation is voluntary and you would be free to withdraw from the project at any time without comment or penalty. Further, we must advise that your participation or non-participation in this project will not effect any current or future involvement you may have with QUT.

For more information contact:

Ian Stoodley (Research Assistant) Ph 3864 4296 <i.stoodley@qut.edu.au> or
Christine Bruce (Information Systems) Ph 3864 2957 <c.bruce@qut.edu.au>

Ways of seeing IT research projects

Consent

By completing this section you indicate that you:

1. acknowledge that the nature of this research and your involvement in the project has been explained to you;

2. understand that confidentiality will be maintained and no identifying information will be released;

3. understand that you may withdraw from this study at any time, without comment or penalty; and

4. understand that your participation in the study is voluntary.

Name .....

Signature ..... **Date** ...../...../.....

If you have any concerns about the ethical conduct of the research you can contact The Secretary, University Human Research Ethics Committee on 3864 2902.

Ways of seeing IT research projects

Interview profile

Please take a moment to answer these questions before the interview begins.

This information will only be used to construct a profile of the participating group. We will not be attempting to correlate research outcomes with individuals or with the various IT sub-disciplines.

Please indicate the response that best describes you, by placing a [X] next to the appropriate choice:

Gender:
[ ] Male
[ ] Female

Age:
[ ] under 30yrs
[ ] 31-40
[ ] 41-50
[ ] 51+

Sub discipline:
[ ] CS
[ ] IS
[ ] DC
[ ] IM
[ ] other

Research Experience:
[ ] Student
[ ] Early Career (completed PhD in last 5 years)
[ ] Experienced
[ ] Not active
[ ] Other _____.

Your participation is appreciated - with thanks, Christine Bruce, Binh Pham and Ian Stoodley.

An Array Processor Architecture for Support Vector Learning

K. To†, C.C. Lim†, A. Beaumont-Smith†, M.J. Liebelt† and W. Marwood*
†CHiPTec, Department of Electrical and Electronic Engineering,
The University of Adelaide, SA 5005, Australia
*Communications Division, DSTO, SA 5108, Australia

Keywords: Support Vector Learning, Array Processor

Abstract

Support vector training requires the evaluation of a quadratic programming (QP) problem which is computationally intensive. In addition, the size of the QP is dependent on the number of training samples and may exceed the memory size. This paper presents a fast parallel implementation of the SVM on an array processor which is optimised for matrix operations. A decomposition algorithm is used to break large scale support vector problems into a fixed size block for efficient processing in the array.

1. Introduction

Support vector learning is computationally demanding to perform. Much of the processing is dominated by the inductive (training) phase. The support vector machine (SVM) inductive algorithm involves solving a positive definite quadratic programming (QP[1]) optimisation problem with a single linear constraint and box inequality constraints. SVM has been applied to classification, regression and time-series prediction of various size problems. The number of variables to be solved is equal to the number of training samples available. In practical applications, this can result in several thousand variables. As a result, SVM learning methods are considered more computationally intensive than many alternative learning methods. The single processor approach commonly used [6], does not have the necessary scalability to cope with the volume of data in large problems. Performance speed-up can be achieved by using parallel processing and appropriate software. This paper describes a new application of a decomposition algorithm on an array processor architecture for large scale support vector learning. The method of decomposition is based on [5]; and the array processor is the MarRISC processor [1] which is a RISC based architecture that is optimised for executing matrix operations.

2. Support Vector Machines

A support vector machine, in its simplest classification form, learns the linear hyperplane from training data by maximising the margin between two classes. It has been adapted to learn non-linear and non-separable distributed data and has also been applied to regression.

The SVM algorithm is based on Vapnik-Chervonenkis (VC) statistical learning theory, which describes the error bound between the *empirical risk* and *expected (true) risk* for a set of approximation function for a given set of data, $X = (\vec{x}_1, \vec{x}_2, \ldots, \vec{x}_l)$ belonging to the class $y = (y_1, y_2, \ldots, y_l)$. The approximation function with the lowest expected risk can be found by minimising the empirical risk and VC-dimension, according to the ***structural risk minimisation principle*** [2, 7]. More precisely, for a set of approximation functions f in a structure that consists of nested subsets of these functions,

$$S_1 \subset S_2 \subset \ldots S_k \subset \ldots$$

where the structure S_k has a *VC-dimension* h_k such that

$$h_1 \leq h_2 \leq \ldots h_k \leq \ldots$$

there exists a function where the sum of the risk bound and the empirical risk is minimised.

The SVM is an approximate implementation of the structural risk minimisation principle in that its objective is to maximise the margin of separation of a linear hyperplane by using an approximation function constructed from the weighted sum of a subset of the training sample set. These samples support the linear hyperplane in the feature space – hence the term *support vectors*.

The two phases of SVM learning are the training (inductive) and the testing (predictive) stages. They are now briefly discussed:

Training stage:

Consider a set of k classified example data for input to the SVM,

$$(\vec{x}_1, y_1), \ldots, (\vec{x}_k, y_k)$$
$$\vec{x}_i \in \Re^n, y_i \in \{-1, +1\}, \forall i \in \{1, \ldots, k\}$$

where $\vec{x}_i$ is the i^{th} input vector that belongs to the binary class y_i. The objective is to find a hyperplane $(\vec{w} \cdot \vec{x}) + b = 0$ by minimising the QP problem given by

$$\min_{\vec{\alpha}} L(\vec{\alpha}) = \min_{\vec{\alpha}} \frac{1}{2} \vec{\alpha}^T Q \vec{\alpha} - [1\ 1\ \ldots\ 1]\vec{\alpha}$$

subject to

$$\vec{\alpha}^T \vec{y} = 0$$

$$0 \leq \alpha_i \leq C, \quad i = 1, \ldots, k$$

[1] Also an abbreviation for the term quadratic program

0-7803-5578-4/99/$10.00©1999 IEEE

Integration of Stereo and Shape from Shading Using Color

Darrell Hougen and Narendra Ahuja *
Beckman Institute
University of Illinois
405 N. Mathews Ave.
Urbana, IL 61801, USA
Ph: 217-244-4174
Email: hougen@uirvld.csl.uiuc.edu

Abstract. This paper describes a method for constructing a depth map that involves the integration of information provided by stereo with that provided by a shape from shading technique. This integration process is facilitated by the use of color images which are easily segmented. The integrated system is able to accurately obtain depth estimates under a wider range of conditions than either stereo alone or shape from shading alone.

1. Introduction

One of the central problems of computer vision is the estimation of three-dimensional surface shape. Several methods have been developed for solving this problem. Some methods, including stereo, use the information provided by the comparison of irradiance patterns from multiple images. Other methods, including shape from shading, use the information present in a single irradiance pattern to estimate shape. Until recently, little research has focused on combining these methods. However, there are significant benefits to be realized from an integrated approach to surface estimation [1,2,8]. In the present case, the use of color images facilitates the integration process.

One of the most widely studied of the comparison based methods of surface estimation is stereo [6,9]. It is well known that absolute depth can be accurately estimated for highly textured surfaces using stereo methods. However, small variations in surface shape cannot be recovered because of limits on the resolvability of densely spaced image features. Moreover, many real surfaces possess large featureless regions for which stereo methods are inaccurate. In addition, the relative accuracy of stereo decreases linearly with increasing depth [10].

Shape from shading is one of the most widely studied methods of estimating surface shape from a single irradiance pattern [7]. Unfortunately, it is difficult to obtain satisfactory results from images of real scenes without a good initial estimate of the surface shape, boundary conditions, and the light source direction. In addition, errors tend to accumulate across an image leading to large errors in global surface shape. Moreover, most real scenes do not satisfy the requirement that the albedo be the same everywhere.

Integrating stereo and shape from shading has several advantages [3,2,8]. The initial depth estimate provided by stereo can be used to provide the initial conditions, boundary conditions, and light source direction that are required by shape from shading, thus eliminating the need for human intervention.

Stereo systems can operate in highly textured regions and at the boundaries between different colored regions where shape from shading systems cannot operate. Conversely, shape from shading methods can be used in large featureless regions where stereo methods are inaccurate. Therefore, an integrated system has the potential of operating under a wider range of conditions than either stereo alone or shape from shading alone.

For stereo systems, errors in surface shape are locally large but are independently distributed so that global errors in surface shape are not cummulative. Conversely, shape from shading can be quite accurate in resolving small variations in surface shape if the boundary conditions are known. Therefore, integration presents the possibility of obtaining both global accuracy and high resolution.

In order for shape from shading to be useful in an integrated system, the problem of albedo variations must be addressed. In most real scenes, including those containing features that are useful for stereo vision, the albedo is not uniform. However, existing shape from shading algorithms require that the albedo be uniform. To circumvent this problem, it is assumed that the surfaces in the scene are composed of regions of piecewise constant color and albedo and can be described by a single reflectance function. Presently, all regions are assumed to have a Lambertian reflectance function. These requirements are actually relaxed by excluding the shape from shading algorithm from regions where the assumptions are invalid.

Based on the above assumptions, images may be segmented into regions of uniform albedo by segmenting them into regions of uniform color. Segmentation using color is more reliable than segmentation along gray level boundaries because color and albedo boundaries generally correspond to material boundaries but gray level boundaries often occur as the result of significant variations of surface geometry, e.g., at a bend or crease in a surface.

The rest of this paper describes a method for estimating surface shape that involves the integration of the informa-

*This research was supported by the Defense Advanced Research Projects Agency and the National Science Foundation under grant IRI-8902728.

Conceptions of an Information System and Their Use in Teaching about IS

Chris Cope, Pat Horan and Mark Garner
La Trobe University, Bendigo, Australia
C.Cope@latrobe.edu.au

Abstract

The question 'What is the nature of an information system?' is fundamental to developing and teaching about information systems, but it is the subject of debate in the IS literature and is not made explicit in most curricula. Our experience of teaching information systems analysis and design to undergraduate students has prompted us to seek better ways of developing students' understanding of the nature of an IS. Our study of IS users, practitioners academics and students, using the phenomenographic research methodology, revealed a hierarchy of four different conceptions of an IS. We have linked this hierarchy to the SOLO taxonomy (Structure of Observed Learning Outcomes) and used it to suggest teaching strategies intended to provide students with systems skills and understanding which will enable them to better interact with IS clients to produce good systems.

Keywords: Information systems conceptions, information systems teaching, analyst-client communication.

Introduction

What is the nature of an information system? This controversial question in IS research is central to the discipline, practice and teaching of IS. This paper considers and reports on:

- the need for IS practitioners and teachers to understand the nature of an IS
- the responsibility of IS education for the development of adequate conceptions of an IS in students
- a review of some of the reported research into the nature of an IS
- the results of an investigation into the conceptions of an IS held by a number of students, users, academics and practitioners
- strategies for assisting students to develop an adequate understanding of the nature of an IS.

We hope that the findings and ideas expressed in this paper will improve our teaching and our students' learning about the nature of an IS, resulting in better-prepared graduates and more informed IS practitioners.

Background

Effective analyst-client communication is crucial to system success. The most important outcome of requirements gathering is a shared perception of the system requirements (Tan 1994, Urquhart 1997). To achieve this outcome, Urquhart found that the analyst and client use interactional tactics (for example imagining and metaphors) in their conversations to facilitate conceptualization of the required IS. Poor communication is likely if the systems analyst is not competent at both interactional tactics and conceptualizing information systems (Urquhart 1997) or the analyst and client bring different conceptual frameworks to the conversations and these differences are not resolved (Tan 1994). Ineffective communication has been consistently related to user-dissatisfaction (Thorn 1995). End-user dissatisfaction is related to poor system utilization (Yaverbaum and Nosek 1992).

Although we recognize the importance of research into conversational techniques during requirements gathering, we are concerned with the problem of conceptualizing information systems. An inadequate IS solution is likely to be produced if a systems analyst:

1. has a poor understanding of the general nature of an IS, as this is likely to result in an inadequate conceptualization of the required IS and/or
2. lacks awareness that the client may have a different perception of the nature of an IS, as this can lead to inadequate communication.

So, where do systems analysts develop their understanding of the general nature of an IS and their awareness of the different perceptions held by their clients? Clearly, IS education has a responsibility to produce graduates who have an adequate understanding of the nature of an IS. We agree with Weber (1996) that most curricula fail to address this

Business Process Reengineering
What are the social implications for the future if we continue to utilise IT to transform organisations?

Tracey Osborne
Griffith University, Australia

Executive Summary
What does the future hold for corporations as we approach a new millennium? According to Meel et al (1994) many organisations need to transform in order to maintain a competitive position within the market place. Industry trends have indicated that current or anticipated economic uncertainty has resulted in many organisations instigating changes to their current operations (Cascio 1993) to improve productivity, customer service, quality, speed and responsiveness within the organisation. But what impact will this have upon the workforce of the future?

Business process reengineering has been utilised as a tool to transform organisations, utilising the enabling characteristics of technology to achieve dramatic improvements in productivity and customer service on a wide scale. Advocates of BPR promote reengineering as empowering and enriching the workforce, whilst less enthusiastic proponents portray the deployment of IT in reengineering initiatives as a dehumanising process, whereby the principle objective is to maintain control over the workforce. The issue of integrating automatic control mechanisms into new systems is a controversial but pertinent issue for organisations of the future, as many corporations are reengineering their operations and developing new information systems.

The technological infrastructure is already available for organisation's to monitor most aspects of our daily lives, therefore, it is feasible that a panoptic[1] society that is overseen by a computerised office manager may become common place in reengineered corporations of the future. Although the author envisages the corporation that is capable of integrating control functions into processes whilst simultaneously enriching organisational life in the redesign process shall achieve a higher level of success and maintainable improvements.

Abstract
Since the conceptualisation of business process reengineering (BPR) in the late eighties and early nineties, interest in the topic has gained momentum, although very few authors have examined the impact upon the workforce and society. This research draws upon existing literature to examine the problems encountered by corporations in the mid 90's, the role of business process reengineering (BPR) and the utilisation of information technology (IT) in the transformation process. The paper also examines the deployment of IT in BPR to examine the impact upon the workforce, the implications for the organisation's social system and the anticipated effects upon employees in the future. The impact upon the workforce has been examined in relation to the effects of downsizing, and the impact of deskilling and controlling the workforce verses the potential to enrich organisational life.

1.0 Introduction
For organisations of the future change is imminent. Current trends have indicated that many organisations have already implemented wide scale changes. However, is this a result of organisational profiteering or has the need for transformation become a competitive necessity? Many organisations have implemented or are in the process of implementing business process reengineering, as the rhetoric promise of reengineering has been exemplified by examples of organisations achieving dramatic improvements in business efficiency and customer service on a wide scale. This paper has been developed by critically evaluating literature on IT, BPR and the social impact of change in relation to the present and future. The objective is to discuss the social implications for the future, if corporation's continue to deploy IT as a mechanism to reengineer the organisation.

---

[1]Panoptic is Greek for 'all seeing'. The members of this type of society are the object of constant surveillance; they may be seen, but they cannot see (Foucault 1979).

Re-Usability Of Legacy Software In An Object-Oriented Application Framework

François Gariépy & Lily Lam
ObjectForm Inc.
555 Dr. Frederik Philips, Suite 400
St. Laurent, Quebec H4M 2X4
CANADA
Tel.: (514)855-4970 Fax: (514)855-4971

ABSTRACT:

Computer-based simulation has become an essential tool for analysis, definition, evaluation and training in a wide range of fields. Faster deployment and broader use are hampered by the cost, time and the variety of advanced technical knowledge required to introduce simulation-based systems. Once the initial base class libraries are created, Object-Oriented analysis and programming increases the reusability of the components. Application frameworks further reduce the development cycle by embedding more domain knowledge in the framework and by promoting re-usability for classes WITHIN the framework. Reusability and life cycle reduction would have much greater value to organizations if a significant portion of inherited software could be reused in new software architectures.

This wealth of legacy software presents several challenges because of the indexing nature of the source language, the original operating system, its logical and data structure and its timing constraints. The focus of this paper is on the reuse, in a new object-oriented application framework, of FORTRAN-and-later source code developed following a top-down data analysis methodology for pseudo-real-time simulation applications. Although some generalization is necessary, three broad solutions are offered: (1) re-implementation in a true object-oriented methodology; (2) encapsulation in a reusable class shell; and, (3) integration as a foreign process.

This paper presents a pragmatic analysis of these solutions to help software engineers leverage legacy software in building a bridge that migrates towards true reusability. The key reuse decision factors are the intrinsic data/control partitioning, the modularity of the architecture, the data/control interface organization and the timing implementation. Each factor is analyzed to identify the criteria for selecting a solution and for minimizing the transition effort. Complete algorithmic re-implementation is ruled out because budgets and schedules generally make it impossible.

INTRODUCTION

The reuse of heritage software (or legacy software) is a major concern for any organization attempting to leverage existing software assets into new opportunities. For most organizations, the consolidation of heritage software with a productivity framework offers a distinct competitive advantage. The object-oriented environment provides the necessary productivity framework for many types of software system development projects. It offers several benefits to the user, including code reusability, life cycle cost reduction and a general improvement in quality. Unfortunately, the issue of heritage software reuse is not well addressed by this framework. A thorough analysis of the needs and requirements of using heritage software in an object oriented framework reveals several solutions.

UNDERSTANDING HERITAGE SOFTWARE

This difficult problem encompasses two main issues: (1) understanding the heritage software design and implementation and; (2) integrating dissimilar software code blocks. Unless a decision is made to reuse heritage software in its original environment and entirely independent from the object oriented framework, the spectrum of solutions require reverse engineering for program understanding.

In this era of software paradigm shifts, the decision to delay the introduction of new and more productive methods, such as object oriented design, may satisfy immediate schedule and cost demands but it is suicidal to the long term competitiveness of an organization. Instead, software architects should carefully analyze real synchronization and interfacing constraints applied to reintegration of heritage and create a hybrid solution that preserves some of the investment in software assets while taking full advantage of advanced frameworks.

Re-integration requirements involve reconstructing the structure of existing software and identifying the data, control and presentation. The software structure is a collection of artifacts used by software engineers when forming mental models of software systems. These artifacts include software components (procedures, modules,