Australasian Journal of Information Systems **Special Issue 2003/2004**

INFORMATION SYSTEMS DEVELOPMENT AS A RESEARCH METHOD

Helen Hasan
School of Economics and Information Systems
University of Wollongong
Wollongong, Australia
Email: hasan@uow.edu.au

ABSTRACT

This paper takes the stance that some cases of information systems development can be considered knowledge creating activities, and, in those cases, information systems development can be a legitimate research method. In these cases not only is knowledge created about the development process itself but also a deeper understanding emerges about the organisational problem that the system is designed to solve. The paper begins with a brief overview of research in the design sciences and a comparison of research methods that are concerned with the design, and use, of information systems. This is followed by an assessment of the way systems development as a research method deals with the scientific research processes of data collection, analysis, synthesis and display. A case study, where the systems development research method was use, is described to illustrate the method and give the reader a better understanding of the approach.

INTRODUCTION

Information systems are modern entities that are distinctive in at least three respects. Firstly, the computer hardware and software artefacts, on which they are based, are tools like no other in the history of mankind (Kaptelinin 1996). Not only can information and communications technologies (ICT) enable the automation of intricate work processes but they also provide support for sophisticated 'knowledge work' (Zuboff 1988, Marcus et al 2002). Secondly, information systems have a socio-technical composition with hardware, software, people and processes integrated into a complex, purposeful whole. Thirdly, ICT products and their use, are evolving at an unparalleled rate, with increases in power and capability matched by decreasing costs. Information Systems (IS) as a field of study, draws its significance from the uniqueness of computer-based information and communication tools and their place in shaping recent human, social and organisational history. IS researchers are distinguished by the fact that they have the difficult and challenging responsibility of understanding, creating and using information systems to best effect.

To reach maturity as a discipline in its own right, the new field of IS borrows research approaches from a wide variety of older disciplines, the closest comparative fields being the engineering traditions and the design sciences. Engineering is a traditional discipline concerning the construction and use of artefacts. The design sciences aim, not only to develop knowledge for the design and realisation of artefacts, but also to improve the understanding of how to solve the social and organisational problems for which the artefact is designed. According to Simon (1981) "design sciences do not tell how things are but how they ought to be to attain some ends". Similarly, advances in the field of IS result from a better understanding of how to develop and use ICT-based tools and what impact they have on the way we work, and live. The question then arises, as posed by Gregor (2002 p12): what constitutes a contribution to knowledge when research is of this type? Papers describing such research typically contain "no hypotheses, no experimental design and no data analysis" (ibid p13) and so often pose a dilemma for reviewers. This does not necessarily invalidate this type of research and the challenge is to conduct and report it in ways that identify the rigour and contribution of the research making it acceptable to journal editors and reviewers.

This paper proposes that, due to their distinctive nature, *information systems development* can be a knowledge creating activity, when those systems relate to emergent knowledge processes (EKP) (Markus et al 2002), and that, in those cases, *information systems development* is a legitimate *research method*. In the process of this type of information systems development, not only is knowledge created about the development process itself but also a deeper understanding emerges about the organisational problem that the system is designed to solve. The paper begins with a brief

overview of research in the design sciences and a comparison of a range of research methods that are concerned with the design, and use, of information systems. This is followed by an assessment of the way systems development as a research method deals with the scientific research processes of data collection, analysis, synthesis and display. A case study, where the systems development research method was adopted, is described and used to gain a better understanding of this approach. The paper then suggests a pragmatic way by which systems development research can be designed, conducted, with the results presented and justified.

RESEARCH IN IS

Information Systems (IS) is a developing and applied field, and members of the IS community are questioning some of the more traditional ideas of what constitutes research and in what ways legitimate research can be conducted in the field. The characteristic of IS that distinguishes it from other management fields in the social sciences is that it concerns the use of "artefacts in human-machine systems" (Gregor 2002). Conversely the characteristic that distinguishes IS from more technical fields, such as Computer Science and Information Technology, is its concern for the human elements in organisational and social systems.

Research can be defined as "diligent and systematic enquiry or investigation into a subject in order to discover facts or principles", which are "accepted or professed rules of action" (The Macquarie Dictionary, 1981). The same source defines knowledge as "acquaintance with facts, truths or principles as from study or investigation" and the outcome of research adds to the body of knowledge of a discipline and it is appropriate to emphasise the strong conceptual link between research and the processes of knowledge discovery and creation. In IS the quality of research is usually determined by the applicability of the knowledge that has been created.

An important determinant of the quality of research is through its relationship to sound theory. IS researchers have frequently borrowed and adapted theories and methodologies from older, more established disciplines. New theories and methodologies are also evolving appropriate to the unique socio-technical nature of the IS field. Kaptelinin (1996) describes the computer as a social and psychological tool unlike any other in the history of human endeavour because of its capacity to mediate human learning and communication. The objects of study in IS research, information systems, are therefore a complex interaction of human, social and technical components that mediate organisational processes. While IS researchers continue to rely on a wide variety of existing and new theories for the range of topics covered by the field, the identification of a single unifying or at least prominent, theory for IS is proving to be difficult.

In a classification of types of theories, among those for analysing, describing, understanding, explaining and predicting, Gregor (2002 p12) proposes that a "theory for design and action" is most relevant for IS research. This design and action theory is about the construction and use of artefacts, and about methodologies and tools for "how to do something" (*ibid*). This type of theory is dynamic so that it can be informed by other theories and can, in turn, provide feedback to augment traditional theories.

To be able to identify what is, and what is not, research in information systems development, it is useful to distinguish between systems that *automate* and those that *informate*, using the term introduced by Zuboff (1988). Where the former are conceptually simpler than the latter, taking an existing manual process and replacing it with a computer-based system. Many *informate* type systems are conceptually complex and the high failure rate of systems such as decision support systems, executive information systems, groupware and knowledge management systems is indicative that they are not well understood. Markus et al (2002) have used the description "systems that support emergent knowledge processes" for these complex *informate* type applications and have shown that they require a new IS design theory. Examples of EKPs are basic research, new product development and strategic business planning. These have the characteristics that there is no best structure or sequence to the process, and have an actor-set that is unpredictable and requires knowledge that is complex, evolving dynamically and distributed across a community of people. EKP involve innovation by sense-making, building knowledge through a recursive, participatory and

evolutionary manner (Boland and Tenkasi 1995). Most knowledge intensive emergent processes involve high-level professional and technical personnel who have a high degree of autonomy and so have challenging information requirements, needing knowledge and expertise to apply this information.

Much of the early research in Information Systems has resulted in improved understanding of methods and techniques for the construction and use of *automate* or low-level *informate* systems. Markus et al (2002) have developed a design theory for *informate* systems to support EKPs however these are generally not standard and tend to be dependent on the specific context. What works in one organisation department or group may not work in another so that much knowledge about such systems is not transferable.

Many IS projects concerned with EKP can be considered a piece of original research where the requirements, design and even implementation is original and contains new knowledge towards a general understanding of how to productively manage data and information in complex situations. Many of these systems evolve through a series of prototypes, which are constantly evaluated with the results fed back into the systems requirements and design. Through the activities of systems analysis and design and the programming of computers to be tools for complex social activities such as EKP, people are engaged in higher mental activities from which new insights and knowledge emerge. This is not a design theory but rather a grounded method of generating theory from a participatory action research process mediated by the unique characteristics of information and communications technology.

SYSTEMS DEVELOPMENT AND RELATED RESEARCH METHODS

Following the lead of Nunamaker et al (1991) this paper will adopt the term *systems development method* (SDM) for the design science research approach in IS. However there are other related approaches, mostly in the realm of qualitative and interpretive research, some of which are action research, grounded theory, engineering, constructivism, pragmatism, tool-mediation of activity and developmental research. These are now presented in order to clarify and enlighten the discussion.

A *systems development method* (SDM) for data collection, analysis and theory building has the reflective and iterative attributes often associated with participatory action research, combining research and practice in such a way that action brings about some situational improvement and research increases the broader understanding of the issue. However there are two particular characteristics that distinguish SDM from the general action research approach. Firstly, in SDM there are always three inter-related domains where this research method can generate knowledge, those of: (a) the techniques of systems development, (b) the properties of system itself, and (c) the situation where the system is to be used. Secondly, the research project is both constrained by the limits that current information technology places on the development of systems and is enabled by the uniqueness of this technology, which can, as a tool, mediate human learning and communication.

SDM also has qualities found in grounded approaches to research. As explained in the award winning paper of Orwlikowski (1995), a grounded approach enables IS research to incorporate the criticality of organisational context in shaping technology use in organisations. Grounded theory is an inductive, discovery methodology with the aims of generating a descriptive and explanatory theory while iteratively gathering rich data from one or more sites. Concepts are suggested by the data rather than imposed from outside and are organised through the identification of recurring themes into theory. SDM however differs from traditional grounded theory research in the way data is coded and categorised.

The term *engineering-type research* is mentioned by Burstein and Gregor (1999) who claim that this type of IS research method is not always recognised as such and is comparatively poorly understood. Engineering is relevant to IS research that studies the design, delivery, use and impact of information and communications technology (ICT) in organisations and society. However, ICT can be considered more than physical artefacts or tools but rather ones that incorporate logic, in the form of software, and interact with people in a way no previous artefact has done. Information systems

are both physical and mental tools so that in IS construction can be considered a form of constructivism that relates closely to SDM. In the context of learning and development, constructivism is a theory, which came out of the work of Piaget and is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own *rules* and *mental models*, which we use to make sense of our experiences, much in the same way as models are constructed though the processes of systems analysis and design.

As construction is a precursor of design, the discipline of engineering is strongly related to the field of design. Niiniluoto (2001) and March & Smith (1995) distinguish design science from the natural or descriptive sciences in research. March & Smith (1995) recognise knowledge in design, and see the design process as one of creating knowledge, which is evident through the building and evaluation of the thing designed. The aim of design research is to explain how and why the constructs, models, methods and instantiations work. Architecture, for example, can be viewed as a design science and one of the concepts emanating from architecture is the concept of patterns (Alexander et al 1977), to explain how good designers conceptualise and reuse their ideas. The concept of pattern has more recently been applied to IT development (Lyon 2000).

Research methods, involving activities of design and construction, are akin to grounded approaches to research such as pragmatism, the philosophy that truth is what works in practice. In IS activities of interest are found in the development of socio-technical systems involving computer-based tools. Typical methods used in IS research, where the design and construction of a system is involved, are observation, action or participant research often with various forms of prototyping (Baskerville & Wood-Harper 1998). The evidence for validity of this type of research, in terms of knowledge creation, is usually referred to as *proof of concept*.

It could be stated that there is a parallel between pragmatic, constructive research methodologies and the developmental methodologies used in practice for systems analysis, design and production. When using the term *methodology* in IS it is often hard to determine where practice stops and research begins. Rather than separate research and practice it may be more beneficial to investigate ways of combining and reconciling the two. A way to do this is by relating research to the concept of tool-mediate activity emanating from the original concepts of Vygotsky (1978). Vygotsky's approach may be called social constructivism because he emphasized the critical importance of culture and the importance of the social context for development.

Vygotsky, and subsequent scholars in Activity Theory such as Leoniev (1981) and Engestrom (1987), saw learning, development and work as holistic human activity, which both mediates, and is mediated by, the tools used and the social context of the activity. This two-way concept of mediation implies that the capability and availability of tools mediates what can be done and the tool, in turn, evolves to hold the historical knowledge of how the community works and is organised. It is through the dynamic process of mediation that learning and development occurs, both in the individual and in the society as a whole (Hasan & Crawford 2002).

The type and quality of the tools used for human work determines, to a much greater extent than they have in the past, the pattern and rate of development. New technology is driving changes to organisational structures and activities and this in turn is placing increasing demands on the capability and capacity of the technology. The changes that ICT, and in particular the Internet, has made to the way information is perceived and used in society today, is illustrative of this concept. It is proposed that research in this area is so closely related to an evolving practice that it must be embedded in, and immediately applicable to, that practice.

An approach that incorporates this concept is development research, which is disciplined investigation conducted in the context of the development of a product or program for the purpose of improving either the thing being developed or the developer. It is therefore ideal for this investigation as it is both contextual and evolutionary, where a prototype model is constructed, used with the target group, which is observed and questioned before the prototype is revised.

THE STAGES OF SYSTEMS DEVELOPMENT RESEARCH

SDM research incorporates many of the concepts mentioned above, design, construction, dynamic tool mediation and developmental aspects. These are found in the five stages of systems development research proposed by Nunamaker et al (1991) namely, concept design, constructing the architecture of the system, prototyping, product development and technology transfer. These stages will be adopted in this paper, although in contrast to Nunamaker et al, it is proposed here that the stages do not follow a linear progression but rather one that is interactive and dynamic as determined by the concept of tool mediation mentioned above. This suggests that what is being done, the research activity, is continually influencing, and being influenced by, the tools used in these five stages. Therefore the distinction between the stages is blurred. They may be continually revisited or, sometimes, one or more may be left out of the process.: The five stages are as follows:

Concept design: In this first stage there needs to be an adaptation and amalgamation of current technical and theoretical advances in the area of interest. The researcher must find, synthesise, use, apply existing knowledge to identify gaps or limitations of existing systems and develop a meaningful research objective. This stage may involve a substantial literature review although the time taken to get research published probably means that the current state of the art is better gleaned from direct communication with practitioners and other researchers in the field. While this stage is more one of locating and synthesising existing knowledge, rather than discovering or creating new knowledge, it could result in the publication of a review paper on the topic.

Constructing the architecture of the system: The second stage is overtly one of new knowledge creation that should be accepted as genuine research. The researcher engages in the creative and innovative design activity of architecture development, defining components, models, algorithms and data structures.

Prototyping*:* This is the stage where proof of concept is often used to demonstrate that a system can be built based on the results of the previous stage. This may be done with a single working prototype or involve the iterative analysis, design and implementation of an evolving prototype. Learning occurs through the evolutionary system building process where insight is gained about the problem and the complexity of the system. The evolutionary prototyping development process includes regular expert/user evaluation feeding back into the systems development process. In many cases of systems development the research stops at this stage because the system fails to meet expectation or is not feasible to be further developed for commercial use. (Koskivaara 2002)

Product development: At the conclusion of the prototyping stage it is possible to freeze and formalise the systems specifications to build, test and evaluate a robust system. In some cases of systems development research there is a particular client sponsoring the research is interested in adopting the systems produced. If commercialisation occurs the new knowledge emerging from the project is often confidential and there is no public release of knowledge.

Technology transfer If the production stage is successful the product may interest a general audience. At this stage it may be possible to evaluate the use of the system with case and field studies or laboratory experiments, consolidating experiences learnt and even developing new theories of use. This may feed back into a new research cycle.

A CASE STUDY IN SYSTEMS DEVELOPMENT

Recent advances in ICT have heightened organisational interest in communities (McLure-Wasko & Faraj 2000) and many organisations are looking to ICT for solutions to such innovative knowledge work practices (Schultze & Boland 2000). The description of EKP, made earlier in this paper, is highly relevant to the complexities of communities of practice and is an area, therefore, where the systems development method is suitable for research. The study, described here, is part of ongoing research by the authors (see for example Hasan & Crawford 2003a,b) and will be used to exemplify the use of the SDM. It concerns the creation, maintainability and sustainability of communities of practice and learning. The design of this research was based on the evolutionary development of a

web-based groupware system, together with protocols for establishing and maintaining communities using it. The research was conducted through observations of a variety of disparate communities supported for the purpose of the research.

The research originated with a community-base program of the Australian Photonics industry, which has a research centre and several small spin-off companies at the Australian Technology Park. This pilot outreach program aimed to

- Increase awareness of the nature of Photonics and career opportunities in the field
- Enable direct links between interested young people, scientists and entrepreneurial business development in the field.
- Provide extended and enriched learning experiences for students in schools, colleges and universities.
- Work cooperatively with teachers, students and parents to create e-learning experiences and learning materials that motivate and engage young people in the adventure of entrepreneurial research and development in Photonics
- Facilitate pathways for people wishing to obtain qualifications and careers in the field.

It was decided to run the pilot program as a community of representatives from the interested parties using a combination of face-to-face workshops and online project-based activities. Technologists and research students at the Technology Park, under the guidance of experienced trainers, collected a suite of ICT tools to support these endeavours, particularly the online community of learning and practice. A small web-based system was built to enable teams to have their own dedicated space to send messages, hold discussions and store files generated in the course of their team's project. This was a rich learning experience for all, particularly the traniers involved in setting up the program. The subsequent research conducted by the authors, has developed and expanded the methods used in this program to study online communities in general. This will now be reported using the five stages outlined above.

Concept design and research questions

There is a growing body of literature (Boland & Tenkasi 1995, Engestrom 1999, Toulmin 1999, Wenger et al 2002), which promotes a view of socially-constructed, collective knowledge as the predominant source of learning, creativity and innovation. Moreover this focus promotes knowing as an activity by specific groups of people in specific circumstances for a specific purpose. Even in highly commercial firms, desirable outcomes are commonly achieved, not at the organisational or individual level, but at the group level in work units, cross-functional teams or informal groups of people who have come together with a common interest. It is not surprising then that the concept of 'community of practice', made popular by the work of Wenger (Wenger et al 2002) to cover an holistic, systemic view of community, has captured the attention of diverse researchers. Distributed communities face challenges when coordinating their knowledge-sharing activities into the social and technical determinants of distributed communities of practice. Innovative information and communications technologies have promised to enable such networks, but research shows their sustainability is still problematic.

From the experience of the pilot Photonics program it was realised that designing and building the system, not only the technology but also the protocols of the communities, was an effective way to conduct research into this problem. A project was begun to study the socio-technical determinants of different and diverse communities through the use not only of innovative groupware technology, but also of techniques, to establish understanding and trust between the participants to enable the community to thrive and achieve its purpose. An inductive developmental approach was taken in this research, recognising the mediating effect of new ICT capability on such collective activity. As researchers we looked for any opportunity to study communities in regional areas where distance motivated the use of online facilities. A development research investigation was conducted in three regionally based communities that were in the process of being established. The specific concepts that became the object of the research were:

- the nexus between learning and practice, (and similarly between knowledge and activity),

- the frequent location of knowledge creation activities in communities as distinct from individuals or formal organisations, and
- the establishment of a viable social-technical model for systems to support communities, particularly those who predominantly communicate online.

Constructing the architecture of the system

In the initial programs on Photonics at the Technology Park, a multifaceted approach had been adopted where scientists, business developers, teachers, technologists, museums and business people contributed to:

- Intensive workshops at the Technology Park,
- An online 'community of interest' that supports sustained creative activity as new materials are built and knowledge is exchanged.
- Community celebrations where young people show their creative work and explain their new learning and interest to members of the community including politicians, local government officials and the media.

This framework helped to establish the architecture of the system, including the technical and social elements. In the three communities that were studied, a single day workshop was held to establish and build the community cohesion and trust. This workshop also determined what would be achieved and how. Teams were established to work together in an extended online period on appropriate project designed to facilitate the desired outcomes, the progress of which was presented at occasional half-day face-to-face or virtual meetings.

Prototyping

For the purposes of the research a prototype of an online support system was constructed modelled on the proprietary one used in the previous Photonics project, which incorporated additional facilities to record all community activities and to regularly poll participants on their views. The interface and functionality of the system could be easily modified as the collected research data were analysed. The communities were each established several months apart so that each one benefited from experiences of the previous ones in an evolutionary process. Preliminary results of this research have been published elsewhere (Hasan & Crawford 2003a,b).

Product development and technology transfer

In addition to the afore-mentioned research publications, the result of this research is a viable product. As the research has progress, technical expertise has been used to ensure that the socio-technical product, which has emerged from this research, is commercially robust. The technical system, together with the process of using it effectively, has reached a level of maturity and is in demand from a number of business and educational organisations. This activity is not, of itself, considered as part of the research.

DESIGNING, PRESENTING AND JUSTIFYING SYSTEMS DEVELOPMENT RESEARCH

Using SDM research

A definition of research, as "diligent and systematic enquiry performed to discover rules of action", is paraphrased from the Introduction to this paper. A cursory overview of the development of *informate* systems that support EKP shows that the following can be considered research using an SDM:

- Creating group decision support systems added to the understanding of group planning and administration processes

- The growth of applications in the field of Artificial Intelligence led to the creation of the field of cognitive science and our understanding of both machine and human information processing.
- The development of executive information systems using online analytic processing systems led to a better understanding of the executive management processes and their information needs.
- The use of expert systems shells to set up knowledge bases has clarified the knowledge of many specific domains such as medical diagnosis.

In the same vein it is claimed that the case described above uses SDM and conforms to the definition of research. IS research aims to increase the understanding of organisational individual and social processes and how information and communications technology tools can support those processes. The output of Stages 1 to 3 can be considered as contributions to new knowledge as follows:

- From Stage 1. This stage provided the research questions and plan for the project as a whole.
- In Stage 2. Here emerged the design of a socio-technical model of sustainable online communities.
- In Stage 3 Here a continuing research process takes place that is adding to the knowledge of how communities can use technological systems for their knowledge management and acting as "proof of concept".

Research design

Although the progress of a systems development project is usually determined by the systems requirements, the fact that it is also research means that there must be a research agenda.
In order to present systems development research as research, the researcher must state at some stage the research problem, the objective and the questions to be addressed in terms of what are the gaps in, or the limitations of, existing knowledge in the area. The researcher must then be able to interpret the findings from the research in terms of its contribution to knowledge. The contribution may be in the innovative nature of the product, its ability to improve performance in the workplace or in the illustration of a new method of product development. There must also be some way that this contribution can be verified, and in systems development research this can be done through the success of the system as proof of concept. This may be supplemented by evaluations of the systems concept or the usability of the system itself, as in the online community project described above.

Dealing with data

In general any research project involves the collection of data by measurement, observation or other form of investigation. The research then consists of processes of data collection, analysis, presentation and either verification of hypotheses or the drawing of some conclusions that add to the accumulated knowledge of the field of study (Miles & Huberman 1994). To be accepted as valid research, the systems development approach must have either some methodical data collection and analysis or an alternative rigorous procedure appropriate for systems development research. Data collected in research using SDM can be empirical, such as that from systems testing, qualitative, such as descriptions of the development process, or even implicit, in that the *data* of interest are embedded in a system's design or implementation. The latter is somewhat unusual but must be considered if the systems development method is to be widely used in IS.
It should be noted that many of the techniques for the design of research and analysis of research data are similar to, and overlap, the IS skills of analysis and design applied to systems including modelling the situation, documentation of the process, justification of choices, planning and conducting systems testing.
Presenting the results of data analysis may take different forms in SDM research. At stage two this may be the architecture itself or its justification. At stage three this may be the system itself as proof of concept. At stage four it may be the impact of the system on an organisation. From a research

perspective a valid outcome may be lessons learnt from a failure with knowledge of what doesn't work. The test by which a systems development project can be considered valid research is by a demonstrable contribution to knowledge and a verifiable statement of what has been learnt.

CONCLUSION AND OBSERVATIONS

IS research has contributed significantly to the knowledge of how ICT systems can be created and used effectively but this is often not recognised as research. Even though the process of data collection, analysis and display are not as easily recognised and the distinctions between them are blurred, these three processes can be said to be present in the systems development approach to research. Certainly the display is evident in the system itself but findings of the research are also evident in innovations to the way that the organisation conducts the activities for which the system was designed and consequent improvements to organisational performance.

Researchers with ICT skills often use this approach but may not have an appreciation of how it constitutes research. We have observed that people with a purely technical focus place more emphasis in getting the product to work than in learning from the process. However it is probably not difficult to insist that systems development research papers contain an explicit statement of the research problem, objective and questions and conclude with a description of the outcomes in terms of the contribution to knowledge. There may often be no clear boundary between aspects of the systems development method and the research method, in many cases of this type of research. This is especially so with complex informate-type systems used to support EKP, but that should not mean that the research is any less valid if a contribution to knowledge can be demonstrated.

It is hoped that a tradition in the use of the systems development research method can be established as legitimate research so that worthy papers can be readily approved for publication.

REFERENCES

Alexander C., Ishikawa S., and Silverstein M (1977) A Pattern Language: Towns, Buildings, Constructions, **Oxford University Press NY.**

Baskerville R., Wood-Harper A.T. (1998) Diversity in information systems action research methods, **European Journal of Information Systems** 7. 90-107.

Blackler F. (1993) Knowledge and the Theory of Organisations: Organisations as Activity Systems and the Reframing of Management. **Journal of Management Studies** 30/6 863-884.

Boland R. Tenkasi R. 1995 Perspective Making and Perspective Taking in Communities of Knowing **Org Science** 6/4 350-372

Burstein F., Gregor S. (1999) The systems development or engineering approach to research in Information Systems: an action research perspective, **Proceedings of ACIS99**, Wellington, NZ, 122-134.

Engeström Y. (1987). **Learning by expanding: An activity-theoretical approach to developmental research**, Orienta-Konsultit, Helsinki.

Engestrom Y. (1999) Innovative Learning in Work Teams: Analysing Cycles of Knowledge Creation in Practice, in Engestrom Y. Miettinen R. Punamaki R. eds **Perspectives on Activity Theory**, Cambridge University Press, Cambridge UK.

Gregor S. (2002) A theory of Theories in Information Systems, in S. Gregor and D. Hart, **Information Systems Foundations: Building the Theoretical Basis**, ANU Canberra, 1-20

Hasan H. and Crawford K. (2002) Codifying or Enabling: the Challenge of Knowledge Management Systems, **Journal of Operation Research**, 54, 184-193

Hasan H. and Crawford K. (2003a) A multifaceted approach to distributed communities of learning and practice, **Proceedings of ISGLOB03, IFIP 8.2/9.3,** Athens.

Hasan H. and Crawford K. (2003b) Socio-Technical Systems for Knowledge Mobilisation in Communities, **Proceeding of ACIS**, Perth.

Kaptelinin (1996) Computer-Mediated Activity: Functional Organs in Social and Developmental Context. In Nardy, B. (Ed.). **Context and Consciousness: Activity Theory and Human-Computer Interactions.** Cambridge, Mass: The MIT Press

Kasanen E, Lukka K Siitonen A (1993) The Constructive Approach in Management Accounting Research, **Journal of Management Accounting Research** (Fall) 243-264.

Koskivaara E. (2002) Design Science Approaches to Information Systems Research, in S. Gregor and D. Hart, **Information Systems Foundations: Building the Theoretical Basis**, ANU Canberra, 205-216.

Leontiev A.N. (1981) **Problems of the Development of Mind** Moscow: Progress

Lyon K.L. (2000) Using Patterns to Capture Tacit Knowledge and Enhance Knowledge Transfer in Virtual Teams, in Y. Malhotra ed, **Knowledge Management and Virtual Organisations**, Idea Group Publishing, Hershey PA.

March S.T., Smith G.F. (1995) Design and natural science research on information technology, **Decision Support Systems**, 15, 251-266.

Markus L. Majchrzak A. Gasser L (2002) A Design Theory for Systems that Support Emergent Knowledge Processes, **MIS Quartery** 26/3 179-212.

McAdam R. and McCreedy S. (1999) A Critical Review of Knowledge Management Models, **The Learning Organisation** 6/3 91-:100.

McLure-Wasko M. and Faraj S. (2000) "It is what one does": why people participate and help other in electronic communities of practice, **Journal of Strategic Information Systems**, 9 155-173.

Miles M. B. and Huberman A. M. (1994) **Qualitative Data Analysis**, Sage Publications, Thousand Oaks, CA.

Niiniluoto I (2001) Futures studies: science or art? **Futures** 33 371-377.

Nunamaker J.F., Chen M., Purdin T. (1991) Systems Development in Information Systems Research, **Journal of Management Information Systems** 7/3 89-106.

Orlikowski W (1993) CASE Tools as Organisational Change: Investigating Incremental and Radical Changes in Systems Development, MIS Quarterly, 17/3.

Schultze U. and Boland R 2000 Knowledge management technology and the reproduction of knowledge work practices. **Journal of Strategic Information Systems**, 9 193-212

Simon H (1981) **The sciences of the artificial**, The MIT Press, Cambridge (MA).

The Macquarie Dictionary (1981), Macquarie University Press, North Ryde, Australia.

Toulmin S. (1999) Knowledge as Shared Procedures, in Engestrom Y. Miettinen R. and Punamaki R. eds **Perspectives on Activity Theory**, Cambridge University Press, Cambridge UK. Pp 70-86.

Wenger E. McDermott R. Snyder W. (2002) **Cultivating Communities of Practice**, Harvard Business School Press, Boston.

Virkkunen J. and Kuutti K. (2000) "Understanding organisational learning by focusing on 'activity systems'", **Accounting, Management and Information Technology** 10 291-319.

Vygotsky, L.S. (1978) **Mind and Society**, Harvard University Press, Cambridge, MA

Zuboff S (1988) **In the Age of the Smart Machine** Heinemann Professional, Oxford