7-12-2006

Design as research: emergent complex activity

Helen M. Hasan
University of Wollongong, hasan@uow.edu.au

Design as research: emergent complex activity

Abstract

There is current interest in design science as a research method in the field of Information Systems. This paper explores this proposition by incorporating established theories into the design research process. These include a view of information systems as essentially socio-technical, notions of tool mediation and expansive learning from Activity Theory and the concept of emergence from Complexity Theory where good design outcomes come from non-deterministic and organic processes. A case of innovative collaborative systems development illustrates how this view of design science may be of value.

Keywords

Design Science, Activity Theory, Complexity Theory, Socio-technical Systems

Disciplines

Business | Social and Behavioral Sciences

Publication Details

This paper was originally published as: Hasan, H, Design as research: emergent complex activity, Proceedings of the 17th Australasian Conference of Information Systems (ACIS 2006), Adelaide, 6-8 December 2006.

Design as Research: Emergent Complex Activity

A/Prof Helen Hasan

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

Abstract

There is current interest in design science as a research method in the field of Information Systems. This paper explores this proposition by incorporating established theories into the design research process. These include a view of information systems as essentially socio-technical, notions of tool mediation and expansive learning from Activity Theory and the concept of emergence from Complexity Theory where good design outcomes come from non-deterministic and organic processes. A case of innovative collaborative systems development illustrates how this view of design science may be of value.

Keywords

Design Science, Activity Theory, Complexity Theory, Socio-technical Systems.

INTRODUCTION

Design is both a verb and a noun. When used as a verb, design is a deliberate planned process aiming at producing an artefact to particular specifications. As a noun, the design of an artefact may co-evolve with its production in an evolutionary, emergent process where experiential learning occurs. It is suggested in this paper that such knowledge creating activity constitutes research in the context of Design Science and warrants more attention as a legitimate research methodology, in the fields of Information Systems (IS).

The multidisciplinary fields of IS have borrowed or adapted research theories and methods from a number of more established fields of study. This is manifested in the variety of opinion both on what are the core elements and what else comes within the scope of the field. The major international IS conferences allow an eclectic mix of themes reflecting a tendency to be inclusive rather than restrictive. It has been noted that 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. IS research draw significance from the uniqueness of computer-based information and communication tools and their place in shaping recent human, social and organisational history. Advances in the field will result from a better understanding of how to develop and use these tools and what impact they have on the way we work, and live. However, there is also some justification for the argument that the fields will only be recognised as mature disciplines when there is a set of specific theories, frameworks and methodologies that define their focus and boundaries. Design Science is a candidate for membership of this set.

This paper brings together a number of general concepts and theories that have had particular relevance for IS. Clearly one basic influence on IS has been the *systems* approach taking concepts from General Systems Theory, Soft Systems, Systems Thinking, and the like. Another is Design Science, which has had some influenced on IS over the last two decades from the work of Simon (1981), March and Smith (1995) and others, but has recently become more prominent in the search for a uniquely IS approach to research (see for example Hevner et al 2004, Marckus et al 2002, Hasan 2003). According to Simon (1981) “design sciences do not tell how things are but how they ought to be to attain some ends”. Design Science aims 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.

Approaching research from the perspectives of Systems Thinking and Design Science poses particular challenges for researchers as to what methods are appropriate and, more fundamentally, what constitutes legitimate research into the design and production of information systems. Papers describing such research typically contain “no hypotheses, no experimental design and no data analysis” (Gregor 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 will analyse a particular case of systems development to explore this problem. In doing so it uses ideas from other areas, namely Activity Theory, Socio-Technical Systems and Complexity Theory, which could help to adapt basic ideas of systems and design to be more appropriate and useful for IS research..

BACKGROUND PROPOSITIONS

There are several inter-related propositions on which this paper is based and which make up a platform for the interpretation of the case of systems design presented later. These are:

- Systems are holistic, integrated, dynamic, purposeful
- Information systems are essentially Socio-Technical Systems
- Activity Theory provides a suitability framework for the study of information systems
- Information systems in the current environment are complex
- Concept from complexity theory have implications for Design Science

Each of these propositions will now be presented in more detail.

The Nature of Systems

A *system* is by definition an assemblage or combination of elements or parts forming a complex inter-related whole that is "more than the sum of its parts". The adjectives holistic, integrated, dynamic and, in particular, purposeful describe systems of which there are many instances such as biological systems, ecology systems, urban systems, organisational systems and information systems, among others. General Systems Theory and Checkland's Soft Systems Methodology are well-known. Systems Thinking is another related conceptual framework that provides a way of understanding the complex real world from a systemic perspective. According to Senge (1994) Systems Thinking is a body of knowledge and tools that has been developed over the past fifty years, to make the patterns clearer, and to help us see how to change them effectively.

Hitchins (2003) describes Systems Thinking as a way of managing complexity by conceiving of and testing ways of changing behaviour *in vitro*, with a view to implementing similar changes *in vivo*. The models that it engenders are, in general, nonlinear because the world they represent is nonlinear. Richmond (1994) defines Systems Thinking as "the art and science of making reliable inferences about behaviour by developing an increasingly deep understanding of underlying structure". It is therefore both a way of looking at a problem and a set of tools to address it.

Such tools occupy the realm of Systems Dynamics which include computer-based modelling and simulation. Techniques such as casual loop diagrams as well as stock and flow based models are often used for both research and practice (see for example Derrick et al 2004). Depending on your view, Systems Dynamics is either a subset or a superset of Systems Thinking. Systems Thinking also forms a rich language for describing a vast array of interrelationships and patterns of change. This tradition should perhaps have a more prominent role.

Socio-Technical Systems

Most introductory textbooks describe the information systems artefact as composed of a variety of component types: hardware, software, storage, processes and people. However in common usage some of these components, particular those made up of people or business processes are often not seen as part of an information system. Phrases such as "using the system", and "putting data into the system" imply that the *system* is seen purely as the technical part. Both research and practice echoe this perception so that often the business process and the human-computer interaction are not incorporated into the system specifications or design. It may be that some of these *softer* parts of the system are difficult or even impossible to *design* in the traditional sense of the term. A basic premise of this paper is that all systems are essentially socio-technical in nature and should be viewed from this perspective in any comprehensive discussion on Design Science.

The term *socio-technical* is commonly applied to the study of the relationships and interrelationships between the social and technical parts of a system, particularly within organisations. The term effectively expresses the intricate relationship between the social and technical elements of any information system. Coakes (2002 p6) describes the goal of socio-technical design as to produce systems capable of self-modification, of adapting to change and of making the most of the creative capacity of the individual for the benefit of the organisation.

Scholtz (2002) also sees the socio-technical perspective as valuing small independent work groups engaged in highly varied tasks, managing their own activities and often supported by technology. These descriptions resonate with the work described here and support the notion that, from this perspective, the applicability of socio-technical principles and the methods of applications associated with them help organisations to explore conflicts and complexity in the human, organisational and technical aspects of change (Coakes 2002).

Activity Theory as a Framework for the Study of Systems

The theory of activity was explicated by Leontiev (1981), based on the psychology of Vygotski (1978) developed in Russia in the early part of the twentieth century. The constructs of Vygotskian psychology that are fundamental to Activity Theory concern those elements of activity and consciousness that distinguish humans from other beings. Essentially, Vygotski (1978) defined human activity as a dialectic relationship between subject and object, i.e. a person working at something as in a socio-technical system. In this dynamic, purposeful relationship the 'always active' subject learns and grows while the object is interpreted and reinterpreted by the subject in the ongoing conduct of the activity. Activity then becomes the indivisible unit of analysis of the situation and, as such, can be used to provide a framework for research.

In the context of IS, Activity Theory places the emphasis on the purpose of the activity for which a system is being used. Within the complex mix of components and their inter-relationships that make up dynamic systems there are issues of instrumentality and agency that must be acknowledged is achieving this purpose. Vygotski (1978) proposed an 'instrumented' structure of human activity within a 'system of interrelationships' between people (Verenikina & Gould 1998) In other words all human activity is purposeful, is carried out through the use of 'tools' and is essentially social. Vygotski also believed that tools play a mediating role in all human activities, which can only be understood in terms of the tools and signs that mediate them. This is a two-way concept of mediation where the capability and availability of tools mediates what is able to be done and tools, in turn, evolve to hold the historical knowledge of how the community behaves and is organised. This is particularly powerful when the tools are computer-based (Kaptelinen 1996). Tools expand our possibility to manipulate and transform objects but also restrict what can be done within the limitation of the tool, which, in turn, often stimulates improvements to the tool (Verenikina & Gould 1998). The formal, or informal, rules of the community, in which the activity occurs, also dynamically mediate the subject-object relationship.

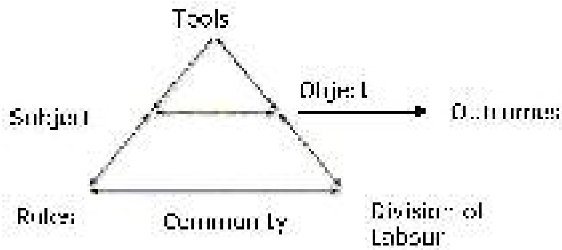

Figure 1. The subject-object relationship, which defines an activity, is mediated by tools and community through rules and division of labour. The subject may be individual or collective and the outcomes of the activity are distinct from its object/purpose (Engeström 1987).

To be able to analyse complex interactions and relationships, Engeström (1987) proposes a new unit of analysis he calls a human activity system. Kuutti and Virkkunen's research (1995) has used activity systems as a representation of the common object of organisational work which cannot be studied by reducing the scope to one or another element, but where a minimum meaningful system as a whole should be taken as the unit of analysis and intervention. Engeström (1987) gave a more concrete expression to this structure in the triangular representation, shown in Figure 1, which is commonly used to depict an activity. The core of an activity is a dialectic relationship between subject (human) and object (purpose) mediated by tools and community.

Engeström (1987) also suggests that it is the internal tensions and contradictions of such an activity system, which includes both historical continuity and locally situated contingency that are the motives for change and development. He paints a picture of dynamic cycles of expansive learning that are of crucial importance to the historical understanding of activity systems. This is manifest in his approach to research and practice known as Developmental Work Research (DWR) where the natural process of expansive learning that occurs in activity systems results in the creation of knowledge.

The Current Complex Environment

We currently dwell in a turbulent environment, in which change constantly occurs and elements in the environment are increasingly interrelated (Robbins, 1990). During the latter part of the past century, the nature of change is frequently revolutionary rather than evolutionary. One possible explanation of this unstable environment is that the progress in information and telecommunication technologies and the inception of the Internet as a global computer network has made the world more interconnected in a manner that has never existed before in the history of mankind and this acts as a catalyst in fostering further change. As a consequence, we can expect that brisk change is a common theme rather than an exception. The implication of this phenomenon poses an immense challenge to academics and practitioners alike to successfully understand and manage organisations as complex entities.

Alain de Vulpian (2005) has another perspective on these global changes. He writes: "I have reached the conviction that we are in the epicentre of a developmental process of civilisation that is carrying us elsewhere, transforming western culture in depth and possibly preparing the way for a worldwide civilisation. This process is extremely complex. It affects all levels of our social life, from the extreme micro (for example the lives of couples and families, networks of friends) to the macro and the mega (for example, the birth of new organisations, the lives of companies and states, or worldwide regulatory bodies). Simplifying things to the utmost, one could say that an explosion of personal autonomy is feeding into and enriching the social fabric, producing extreme levels of complex interaction through which several technical and technological progresses are selected; and these selections themselves reinforce the levels of individual autonomy and social complexity. These interdependences are bringing to life a new form of society which selects and is selected by new forms of governance."

Senge (1994) also notes that business is becoming more complex, dynamic, and globally competitive in his work on learning organisations "where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together." Senge makes a case for Systems Thinking as the discipline that will give a better understanding of this complex world. He writes; "from a very early age, we are taught to break apart problems, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay a hidden, enormous price. We can no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole."

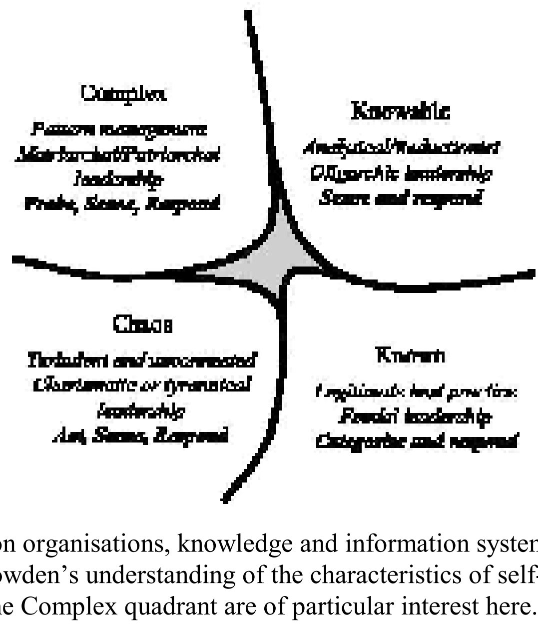

Figure 2 The four perspectives on organisations, knowledge and information systems depicted in the Cynefin framework (Snowden 2002). Snowden's understanding of the characteristics of self-determination, emergence and organic forms that apply in the Complex quadrant are of particular interest here.

A complex system is any system which involves a number of elements, arranged in structure(s) which go through processes of change that are not describable by a single rule nor are reducible to only one level of explanation; these levels often include features whose emergence cannot be predicted from their current specifications.

Complex systems theory also includes the study of the interactions of the many parts of the system. Previously, when studying a subject, researchers tended to use a reductionist approach which attempted to summarise the dynamics, processes, and change that occurred in terms of lowest common denominators and the simplest, yet most widely provable and applicable elegant explanations. Since the advent of powerful computers, which can handle huge amounts of data, researchers can study the complexity of factors involved in a subject and see what insights that complexity yields without simplification or reduction. Complexity itself is characterised by a number of important characteristics such as self-organization, non-linearity and emergence.

There is a current interest and growing understanding of how to work with complex systems. Snowden (2002) states that in complex situations it is not possible to predict or determine outcomes in advance, and cause and effect is only seen in hindsight. He describes how meaningful patterns of behaviour emerge that can be encouraged, but not mandated or controlled. According to Snowden, attractors and barriers can be used to enhance the likelihood of desirable outcomes, and indeed innovation and organisational learning. Snowden proposes the Cynefin model which utilises the self-organising capabilities of informal communities to understand how to manage knowledge both as a thing and a flow. Rather than implying that chaos is the natural outcome of the self-organising capabilities of informal communities, Snowden has faith in the human capability to create order and predictability though collective and individual acts of freewill. As shown in Figure 2 the Cynefin model is a knowledge space with four domains which set the context for collective decision making: two domains of order, the known and the knowable, the domain of complexity and the domain of chaos. Each has a different mode of community behaviour and each implies a different form of management and a different leadership style with the adoption of different tools, practices and conceptual understanding. Using the Cynefin model one is able to see how organisations and their information systems can be part mechanistic and part organic.

Implications for Design Science

The background material presented in this section of the paper began with the well-accepted proposition that systems are holistic, integrated, dynamic and purposeful. It has emphasised the assertion that information systems are essentially socio-technical in the sense that the human and social factors are an integral part of any information systems and at least as important as the technical parts. These softer parts of information systems are however often more difficult to understand and to deliberately design than the more technical parts of the system. A Systems Thinking approach to research brings a holistic and integrated perspective to IS projects and provides system dynamics tools through modelling and simulation. It does however tend to assume a rational and ordered view of systems where cause and effect relationships can be determined and represented in a model of the system.

Activity Theory is compatible with the accepted wisdom of Systems Thinking and Socio-Technical Systems. It provides a suitability framework for the study of information systems but in a more organic and less deterministic way. The world is interpreted through a framework in which *activity* is the indivisible unit of analysis where an *activity* is the dynamic tool-mediated dialectic of subject and object, as described above. Within an activity there is also a dialectic relationship between learning and doing as expressed in the notion of expansive learning. This encompasses the principles of self-organisation and emergence which are prominent in complexity theory.

It is proposed therefore that since information systems in the current environment are complex, a framework grounded in Activity Theory, incorporating concepts from complexity theory, may be eminently suitable for many areas of research. The case presented here will be used to instantiate this. It is proposed also that this approach has implications for Design Science.

The two processes of design and emergence are often conceived as mutually exclusive in nature. A more productive view could be to see these processes as complementing each other in design projects so that a system can be partly designed but with allowance for emergent properties as well. This may enhance the development of the social aspects of computer-based artefacts when they are considered to be Socio-Technical Systems.

A CASE OF COMPLEX SYSTEMS DESIGN

An Overview of the Case

The case presented here concerns a research and development project sponsored by a military organisation to create a system in the context of a study of network-centric warfare. The particular aspect of the study that led to the system described here investigates how people and groups coordinate, cooperate and share information, especially in a military network-centric environment. Of particular interest are human or group related factors that may impede or even prevent the successful achievement of such coordination, cooperation and information sharing despite the availability or presence of the technological capability to support it (Hart et al 2006). While the proposed system appeared to have the potential to advance their understanding of this multifaceted topic, the intended and expected outcomes of the project were not tightly specified at the onset.

The technical component of the system is a computerised team version of the ancient strategy game of Go, which was originally developed in China between three and four millennia ago. This client-server version of the game is called Go*Team[1] is an adaptation of the traditional game of Go. Figure 2 shows the server screen during a game. The client screens for each player show only a partial view of the board (see Figure 4) so that there is a need for team members to communication their view of the board to others as well as to discuss strategies. Players on the same team therefore make use of modern communication tools such as email, voice over IP, group support systems, chat rooms and the like to effect the cooperation and coordination they need to successfully play the game.

Unlike standard Go, in which the players take turns to place their stones, teams playing Go*Team no longer have to take turns; a team's next turn can be taken after a "relaxation time", specified via the server, regardless of whether or not the opposing team has done anything in the interim. There is also no preset command structure built into the Go*Team game. As far as the game software is concerned all team members are peers; there is no "team leader", or team member with more power or capabilities than others. The Go*Team game has, therefore, been created to place its players in an environment exhibiting a number of the features outlined above in order to explore how they function in that environment, the techniques they prefer to use, the techniques that are more successful, and the barriers that may inhibit them from operating as effectively as they otherwise might.

Figure 3 An example of the server screen of the Go*Team game.

[1] Go*Team is the creation of Dr Dennis Hart at the Australian National University and is being developed at the Defence Systems Analysis Division, Defence Science and Technology Organisation, Department of Defence Canberra

Figure 4 An example of two client screens of the Go*Team game showing the different views of two players on the same team.

As declared by Hart el al (2006) this team version of the Go game is designed to embed its players in an environment that involves:

- conflict (with the other team or teams involved in the game);
- cooperation and coordination, but also competition (with and between the players in one's own team);
- information sharing (through the need to continually share information in order to synthesize and integrate, in a dynamic situation, multiple fragmentary and local perspectives into an overall situational picture);
- timely and appropriate decision making (through the need to balance the time taken for adequate situational analysis and the pressure to avoid being overtaken by events).

The Current State and Prospects of the Go*Team System

The project to develop Go*Team has taken over a year from its original inception to its current state where the software application is operational and several trial games have been played. There are a variety of stakeholders involved in the project. The proposal came from a researcher who originally conceived of the idea and was given leave for much of the development time to work with others on the project. These included software and interface developers, other researchers and the sponsors of the project from the military. The project currently finds itself in an incongruous situation where the original sponsors are ambivalent about the future of the system and may shelve it even though it may have commercial value for team training and team-behaviour profiling. The researchers are however excited about the prospects of using it to study a variety of issues related to the strategic decision-making behaviour of teams, in particular:

- Conflict, Cooperation and Competition
- Information, Shared Understanding and Integration
- Trust, Collaboration and Information Sharing
- Uncertainty, Confusion and Unpredictability
- Tempo and Decision-Making

Taking a socio-technical systemic view of Go*Team quickly reveals the complexity both of the system itself and the context of its use. There are many technical and human components involved with multiple relationships between them. There is uncertainty among the developers, sponsors and the researchers as to the purpose of the system. The latter see Go*Team as a tool for research into aspects of network-centric organisations. They are in the process of designing protocols for conducting research with Go*Team, identifying constructs as dependent and independent variables as well as measures for them. The others stakeholders are less clear on this. The view of the system from its originator and principle developer of the project is that Go*Team is designed to "embed its players in an environment that involves conflict (with the other team or teams involved in the game), cooperation and coordination, but also competition (with and between the players in one's own team), uncertainty, complexity and information sharing (through the need to continually synthesize, in a dynamic situation, multiple fragmentary and local perspectives into an overall situational picture), timely and appropriate decision making (through the need to balance the time taken for adequate situational analysis and the pressure to avoid being overtaken by events)" (Hart et al 2005). The question now arises as to what outcomes can be achieved when this is done and for whom.

An Activity Theory Analysis of the Case

In this section of the paper the Go*Team project and system is analysed in terms of Activity Theory using *activity* as the unit of analysis. This logically begins with the identification of the activities involved, ie who is doing what, by their object and purpose.

Bødker's (1990) pioneering work on the application of Activity Theory to computing nominates two basic activities in ICT-based projects, namely those of design and use. In this case the researchers can be nominated as a 'collective subject' of a 'use activity' with a reasonably coherent view of the *object* of their research activity, which is essential for a collective activity. The Go*Team system is, and will continue to be, a mediating tool of this activity. The researchers have been aware of the Go*Team project throughout the development of the system, offering advice and suggestions. The Go*Team system development and the research activity have co-evolved to a considerable extent.

The activity of the sponsoring group within the military is interesting as they could be considered as potential users of the system, possibly for team training or team member profiling. However, despite the fact that they originally approved and funded the project, they have not shown a great deal of interest in the system itself and are mainly concerned at this stage that the project report be submitted on time. It may be that their motive lies mainly in conducting projects that appear to be innovative and high-tech rather than actually producing anything of use. Thus the *object* of their activity is the completion of the *project* rather than a 'use activity' which uses the system as a mediating tool.

The development activity is equally non-coherent and ambiguous. All the members of the development team saw creating the system as a piece of software as the *object* of their activity except the originator of the project, who saw it as a sophisticated game. As the object of an activity defines it, the development of the system is probably best understood as made up of two different activities with two different objects, namely the software development activity and the game creation activity. It was clear that the main motivation of the originator of the project was to the game through which to engage players (see previous quote from Hart et al 2006). This latter activity had a close relationship with the research activity as the *subject* was also a researcher. The other developers most probably viewed the object of their activity only as the software application and were satisfied that they had achieved their desired outcome, namely a working technical artefact.

Using the framework of Activity Theory a summary of the project depicts it as a set of multiple activities with complex interrelationships. There are four prominent activities, namely the game-producing activity, the project conducting activity, the systems development activity and the research use activity. As described by Engeström (1987) there are contradictions within and between these activities, as well as between each activity and an advanced form of the activity. This latter contraction was particularly noticeable in the game-producing and research use activities. The other two activities, technical development and project oversight were more straight-forward, the latter being particularly bureaucratic in nature.

There was a great deal of interaction between the game-producing and research-use activities, resulting in expansive learning on how the system should be designed in order for it to serve its purpose. Both these activities took a socio-technical perspective and were sensitive to the dynamic context within which the system was being developed and where it would be used. The focus of the military on network-centric concepts is itself full of contradictions. There is no universally accepted definition of the term. The researchers describe a network-centric approach as one which enables workers/fighters/members of an organisation to create and leverage an information advantage to increase competitive advantage through the collaboration of small and agile self-directed teams. The capability to do this results from developments of ICT and of the change from the industrial to the information age. Many in the military equate network-centric with technology but, from the research perspective, the focus is no longer on technologies but on people organisations and organisational behaviour.

The Activity Theory framework has provided a better explanation of the case than a purely systems one. Consideration has been give to modelling the systems dynamics when Go*Team is played and using findings from Go*Team research to model the workings of network-centric organisational structures. However, it has not been as easy to identify the components of these systems as it has been to nominate the make up of the four activities described above. On the other hand the descriptive nature of the activity-based view has good explanatory value but does not have the predictive power of a systems model.

DISCUSSION

In the course of this case, a furthering of knowledge has taken place concerning the creation of the end-design of socio-technical information system represented by Go*Team, the process of its development and its intended use for research into human factors of network-centricity. The interrelated activities in the case, presented and analysed above, add to the understanding of Design Science at a number of levels.

At one level, the research activity will continue to use the Go*Team system. Thus the project activity has, as an outcome, the successful design of an innovative tool for research into topics, such as network centric organisational configurations, that are not well understood. The case therefore informs those, who may want to create, adapt or use such tools for research into complex organisational phenomena created by, or involving, information systems. In other words the system design is innovative and a contribution to knowledge in itself.

At another level, the case illustrates a process of information system development where the initial specifications are vague and there are contradictory expectations among the stakeholders. The most exciting outcome from this activity may be the expansive learning that has occurred, as the design of some aspects of the system has been allowed to emerge while others have been more carefully planned. It is probably true to say that the technological aspects of the system respond better to logical planning whereas the non-technical parts tend to emerge, including the purpose of the end-product of the developmental activity.

At a third level knowledge has been created in the area of the research topic, as the researchers and developers have co-evolved the system and the research design. Observing and experiencing what prototypes of the system could do, has inspired the research to think in new ways about the research issues. One of these, the balance of competition with collaboration and cooperation within work teams has received some attention of late (see for example the work of Angehrn, & Loebbecke 2003). The Go*Team game has been designed to encourage the need to cooperate in teams within a competitive environment under stressful conditions requiring strategic decision-making. By creating a system to mimic what occurs in real life, the researchers have a clearer understanding of the real-life conditions they are studying. It is clear for example that what constitutes success for the organisation may not be the same as that for the team or for the individual. The number and permutations of variables that can be manipulated in Go*Team is substantial and their interpretation in terms of real world constructs quite a challenge.

So what can this case, and the way it has been presented and analysed here, tell use about Design Science and its use for research? It has been argued that this is indeed legitimate research through the learning and knowledge creation that has taken place at a number of levels. What this paper has attempted to do has been to incorporate a number of established general theories and perspectives into the design research process. There has been an effort to maintain a holistic systemic approach within the perspective where information systems should always be viewed as socio-technical in nature. The analysis has used *activity,* as defined within Activity Theory, as the unit of analysis, bringing with it notions of tool mediation and expansive learning. The concept of emergence has been brought in from Complexity Theory to allow the system's design to evolve through a process that is part deterministic but also part organic.

The conclusion is therefore that Design Science is eminently suited to IS research but may needs to be combined with other theories and ways of thinking to be appropriate for the research as organizations and their environment become more complex and dynamic.

REFERENCES

Angehrn, A.A. and C. Loebbecke (2003) "Open Source Communities Reflecting Co-opetitive Learning and Knowledge Exchange Networks", *Proceedings of DSS* 2004, Prato, Italy

Bødker S. (1990) *Through the Interface: a Human Activity Approach to User Interface Design*, Hillsdale, NJ, Erlbaum.

Coakes E (2002) "Knowledge Management: A SocioTechnical Perspective", in E. Coakes, D Willis and S. Clarke eds, *Knowledge Management in the SocioTechnical World*, Springer- Verlag London, 4-14.

Derrick S., Winch G., Badger B., Chandler J., Lovett J., Nokes T. (2004) "Evaluating the impacts of time-reduction legislation on junior doctor training and service", *Proceedings of the International Systems Dynamics Conference*.

de Vulpian A. (2005) "Listening to ordinary people: The process of civilisation that is at work leads to a hypercomplex society and new forms of governance", notes of Keynote presentation, SOL, Vienna.

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

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

Hart D., Eronen M., Jagiello J., and Warne L. (2006) "Go*Team: A Team Version of Go for Investigating Cooperation, Coordination and Information Sharing in Network-Centric Warfare Environments", *Proceedings of SinTect06*, Melbourne.

Hasan H. (2003) "Knowledge Creation through Systems Development", *Proceedings of ISD2003* Melbourne.

Hevner, A., March, S. T., Park, J. and Ram, S (2004). "Design Science Research in Information Systems", *MIS Quarterly* 28:1, pp. 75-105.

Hitchins D. (2003) *Advanced Systems Thinking, Engineering, and Management*, Artech House.

Kaptelinin V. (1996) "Activity Theory: Implications for Human-Computer Interaction" in B.Nardi Ed *Context and Consciousness*: MIT Press, 103-116.

Kuutti K and Vikkunen J (1995) "Organisational Memory and Learning Network Organisation: the Case of Finnish Labour protection Inspectors", *Proceedings of HICSS28*.

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

March, S.T. and Smith, G. (1995) "Design and Natural Science Research on Information Technology", *Decision Support Systems* 15:4, pp. 251-266.

Markus, M.L., Majchrzak, A., and Gasser, L., (2002) "A Design Theory for Systems that Support Emergent Knowledge Processes", *MIS Quarterly* 26:3, pp. 179-212.

Richmond B (1994) "Systems Dynamic/Systems Thinking: Let's just get on with it", *presented at the International Systems Dynamics Conference*, Sterling Scotland.

Robbins, S.P. (1990) *Organization Theory: Structure, Design, and Applications* (3rd ed). Englewood Cliffs, New Jersey: Prentice-Hall.

Scholtz V. (2002) "Managing Knowledge in a Knowledge Business", in E. Coakes, D Willis and S. Clarke eds, *Knowledge Management in the SocioTechnical World*, Springer- Verlag London, 43-51.

Senge P. (1994) *The Fifth Discipline: The Art and Practice of the Learning Organization*. Doubleday.

Simon, H.A. (1981) The Sciences of the Artificial, MIT Press, Cambridge, MA,.

Snowden D. (2002) "Complex acts of knowing: paradox and descriptive self-awareness", *Journal of Knowledge Management*, 6/2 100-111.

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

Verenikina I. and E. Gould (1998) "Cultural-Historical Psychology and Activity Theory" in Hasan H, Gould E. and Hyland P. (eds) *Information Systems and Activity Theory: Tools in Context* Wollongong Uni Press. 1-18.