Interpretive research methods in computer science

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> *"[A]ll researchers interpret the world through some sort of conceptual lens formed by their beliefs, previous experiences, existing knowledge, assumptions about the world and theories about knowledge and how it is accrued. The researcher's conceptual lens acts as a filter: the importance placed on the huge range of observations made in the field (choosing to record or note some observations and not others, for example) is partly determined by this filter" (Carroll and Swatman, 2000, pp.118-119).*

Introduction

Research is interpretive if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents and other artefacts. In information systems interpretive research is "aimed at producing an understanding of the context of the information system and the process whereby the information system influences and is influenced by its context" (Walsham, 1993). Interpretive research often involves using qualitative methods from which to understand the data collected and analysed during the research process. Nevertheless research is not necessarily interpretive just because the type of data collected is qualitative. Moreover there are ways of using numerical data in interpretive research, as there are ways within traditional research of using non-quantitative data. The most important distinction between traditional research approaches and interpretive research are the underlying philosophical assumptions. A key task in interpretive research is seeking meaning in context - the subject matter must be set in its social and historical context so the reader can see how the current situation emerged (Klein and Myers, 1999). In addition because interpretive research is undertaken with different assumptions about knowledge and being it is necessary for the researcher to make clear the ontological and epistemological underpinnings of the research.

Experimental software engineering

Experimental software engineering[1] (Wohlin et al. 2000) is a sub-field of software engineering. ESE aims at applying empirical theories and methods for understanding and improving the software development process in organizations. ESE is a multi-disciplinary field, building upon subsidiary fields such as statistics, sociology, psychology, and computer science. The main objective of ESE is to evaluate tools, techniques, and technologies used in software engineering empirically, and thereby enhancing the state of the art and practice in software engineering. The method employed to achieve the goal is to run empirical investigations with the software development process as the object of study.

Wohlin et al. (2000) provides a five step research method for doing software engineering experiments:

1. Experiment definition. In this step the hypothesis is defined, along with the objectives and goals of the experiment. The hypothesis, at this stage, need not be formally stated, but should be stated clearly. The objective and goals are found by asking the following questions: what is studied? (object of study), what is the purpose of the experiment? which effect is studied? (quality focus) whose view is assumed? (perspective of the study) and where is the study conducted? (context).
2. Experiment planning. At this stage, the hypothesis is formalized including a null hypothesis. Input/independent variables and output/dependent variables are determined. A suitable experiment design is chosen, and the potential validity problems with the results are discussed.
3. Experiment operation. Subjects and the materials needed (for data collection forms) for the experiment is prepared, before executing the experiment. The primary objective of this stage is to gather data for the next step.
4. Analysis and interpretation. Descriptive statistics are used to understand the data gathered during step three. A possible reduction of the data set must be

[1] Abbreviated to ESE hereafter.

considered. After the data has been reduced, a hypothesis test is performed using statistical techniques.

5. Presentation and package. This stage is concerned with presenting and packaging the findings. It is important that the experiment design is clear, to allow for replication as this is an important mechanism for validating the findings.

Experimental software engineering is based on a hypothetic-deductive research model. The primary problem facing any empirical researcher is the wealth and complexity of the real world. The hypothetic-deductive research model 'solves' this by reducing the scope of the empirical enquiry. The controlled experiment is a good example of such a reduction, where the empirical world is reduced to a set of independent and dependent variables, subjects, and the treatments applied to the subjects. The ontology of this research philosophy is that the real world can be divided into small bits that can later be reassembled into a complete picture.

Towards interpretive software engineering

Recent studies (Conradi and Fugetta 2003, Dybå 2001) warrant the need for increased awareness in ESE research. This has implications on the data material available. Tools, techniques, and methods provide us with quantitative data that we may analyse statistically. Empirical software engineering's current focus on hypothetic-deductive research reinforces the disciplines focus on quantifiable objects of study. However, doing investigations including the organizational dimension, we are faced with a whole array of other data sources to analyse: meeting minutes, internal memos, e-mails, contracts, handbooks of all sorts, staged scenarios (i.e. usability testing) and ethnographic experience renditions (i.e. anthropology-like observations), just to mention a few. A common denominator of these data sources is that they are all documented in a non-numerical fashion, textually or by visio/audio recordings, (which are often reduced to text), and therefore qualitative. In other words, empirical investigations that include the organizational and social dimensions require methods for doing textual analysis to enrich the research within the field.

While there exists qualitative research within ESE (Seaman 1999, Dingsøyr 2002), most published empirical software engineering research is hypothetic-deductive. An approach to empirical research based on textual data is interpretive research. This approach is currently being used within parts of the information systems community (Walsham 1992, Myers 1992, Ciborra 2004). The title *interpretive* should not be understood as exclusive, in that there is no interpretation in other methods for investigations. Interpretative, in this case, means that the entire research effort focuses on the researcher continuously interpreting data, sources, and results produced by different methods for gathering data and analysis of these.

Case study research

Taking an interpretivist philosphical stance Walsham (1993) would claim that, "the most appropriate method for conducting empirical research in the interpretive tradition is the in-depth case study" (p.14). Case study research can be classified as a qualitative method, and, the purpose of which is to try to understand, or interpret, phenomena in terms of the subjective meanings people bring to them (Denzin, 1994). Klein and Myers (1999) point out "positive criteria...are inappropriate for interpretive research" (p.68). The work of Yin (1994) on Case Study Research Design is recognised and cited by many IS researchers as providing an important contribution to case study design. According to Yin (1994), a case study is defined as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (*ibid*. p.13). However, the nearest the author comes to addressing the challenge of 'quality' in case study design is through the use of a case study protocol. He quite correctly deduces that: "A case study protocol is more than an instrument. The protocol contains the instrument but also contains the procedures and the general rules that should be followed in using the instrument." (*ibid*. p.63). He maintains that the protocol should have the following sections: an overview of the case study project, field procedures, case study questions, and a guide for the case study report. All of these are important but the problem is that it

often difficult to accurately document this level of detail at the beginning of the research project.

Like Yin (1994), the research of Walsham (1995) is recognised and cited by many as providing an important contribution to the nature and method for interpretive case studies. He also recognised the lack of "a synthesised view of the nature and conduct of case studies with specific reference to the field of computer-based IS" (*ibid.* p.74). Walsham (1995) discusses: the research tradition of interpretive research, the use of theory in interpretive studies, four types of generalisations (extending Yin's work), and conduct of empirical work.

Principles and quality guidelines for interpretive research

Interpretive field research includes in-depth case studies and ethnographies. Klein and Myers (1999) comment that as "the interest in interpretative research has increased...researchers, reviewers and editors have raised questions about how interpretive field reasearch should be conducted and how its quality can be assessed" (p.67). They have devised a set of principles for conducting and evaluating interpretive field studies in IS (Klein and Myers, 1999). The principles they propose are fundamental ideas derived from philosophical writings that mostly to the conduct and evaluation of interpretive research in the hermeneutic nature. Most importantly, they conclude that,

> "while not all of the principles may apply in every situation, their systematic consideration is likely to improve the quality of future interpretive field research in information systems (especially that of a hermeneutic nature)" (*ibid*. p.70).

The protocol steps described by Yin (1994) would be of particular use for IS case study research if they were components of a more detailed set of practical guidelines. Atkins and Sampson (2002) have provided more practical critical appraisal guidelines for conducting single case study research in the interpretive tradition. The purpose of which is to provide a means to validate both academic and practitioner sourced literature, through the use of hierarchies of evidence.

Social theories for understanding IT in an organisation

So far we have discussed the motivation for using interpretive methods for enhancing ESE research and described interpretive case studies. Depending on the research focus, interpretation can be aided by choosing one or several social theories in order to understand the relationships between work, people and technology. In addition, the use of technology as an aspect in such theory is important for the subject of study. In the following sections we will describe two social theories[2] for interpretation, namely Actor Network Theory and Activity Theory.

Activity theory (AT)

Kutti (1991) states that there has always been a dichotomy in the behavioural and the social sciences between the individual and the social. A solution to this is an intermediary concept which is the *activity*, which incorporates both the individual human agency as well as the social context. An activity is seen as a minimal meaningful context for individual actions and a suitable basic unit for analysis. An activity is better defined than an arbitrary context, but also more manageable than a whole social system. AT is a philosophical framework for studying different forms of human praxis as processes of development, where both the individual and the social levels are interlinked (Kutti, 1991) It draws on German philosophy (Kant and Hegel), the writings of Marx and Engels on the concept of work as well as the Soviet cultural-historical school of psychology founded by Vygotski (1978), Leontjev (1978, 1981) and Lurija.

The main concepts for activity theory are the following:

1. Activity: a fundamental type of context (meaningless to study smaller objects of research for essentially human qualities without loosing the essence of the phenomenon in the basic context.

[2] Bratteteig and Gregory (1999) describe other social theories such as Structuration Theory (Orlikowsky), Interaction Theory (Grounded Theory) as well as Speech Act Theory (Suchman).

2. An activity has an active *subject* (individual or collective) who understands the motive of the activity – the *object*. There may be non-active participants in the activity – i.e. they do not know the motive/object ("the boss knows").
3. The *transformation* of the object towards some desired state is what motivates the existence of an activity.
4. An activity exists in a *material environment* and *transforms* it. (the term material comes from Marxist philosophy and signifies not only "touchable" things but everything conscious which exists outside the individual.
5. An activity is a *historically* developing phenomenon.
6. An activity is a collective phenomenon.
7. Individuals can participate in several activities - basic units of development and human life.
8. When crossing organizational or other conceived borders of an activity, only inclusion of active subjects sharing an object is relevant.
9. Activities temporarily merge. Actions are usually polymotivated, that is they are simultaneously part of separate "overlapping" activities.
10. *Contradictions* are the force behind the development of an activity
11. *Primary contradictions* between the objects or outcomes of two separate activities may introduce secondary contradictions into the activities.(Engestrøm 2000)
12. An activity is realized through the conscious and purposeful actions by participants.
13. Relationships within an activity are *culturally* mediated.

Engestrøms (1987) structural model of activity is shown below. The binary relationship between subject and object of activity is replaced with a mediated relationship through a "tool or instrument" which is history etc. Also there is a relationship between the subject and the *community* (who share the same object) which is also mediated by *rules*. Finally the relationship between community and object is mediated by "division of labour". The mediating members are continuously being reconstructed during the existence of the activity - the activity results in an outcome.

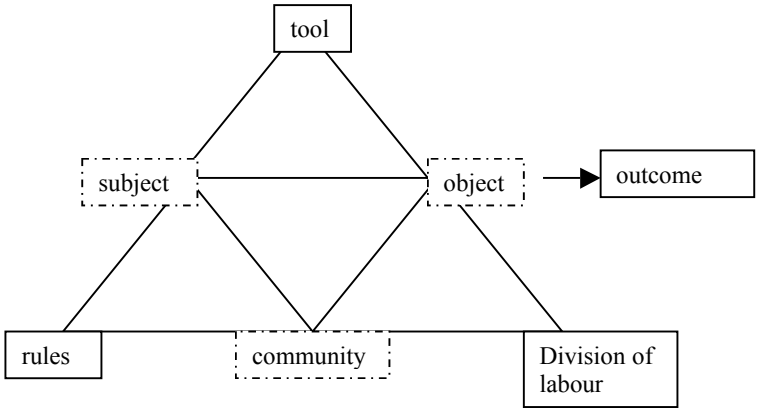

Fig. 1 Basic structure of an activity

AT identifies a three-level hierarchy of collaborative activity (Engestrøm et.al. 1997): the co-ordinated, the co-operative and co-construction. There are dynamic transformations between the levels of collaborative activities, shown at Figure 2 below.

Co-construction

Reflection on the Object of work ↑ ↓ Implementation: Stabilizing the Object of work

Co-operation

Reflection on the Means of work ↑ ↓ Routinization: Stabilizing the Means of work

Co-ordination

Fig.2. The dynamics of cooperative work

Actor network theory (ANT)

Actor network theory is based on the works of Callon (1986, 1991) and Latour (1987). "Actor Network Theory views society as a completely interwoven socio-technical web"

(Hanseth and Monteiro, 1997, p. 2). The theory has ties to semiotics which is the study of order-building (Akrich and Latour, 1992, p.259) and includes both human and non-human entities in addition to signs. In attributing symmetry to all these entities, technology, amongst others, gets promoted to the status of actor. This allows a more detailed look at technology and the role it plays through the hands of the social entities that make it, appropriate it and inscribe motivations and abilities into it, or with it. This contrasts with the other social theories mentioned previously, which all view technology as having enabling or restricting qualities but still see it as secondary to the main focus of the theories. It is important to remember that this promotion of technology's status in ANT is in fact the act of the social actors and is an inherent part of modern organization of society as such. The social actors use technology to their own or others end, be it conscious or not, depending on how the actor network gets aligned.

The basic concepts are described by Callon (1986):

1. Actor: any element which bends space around itself in trying to make other elements adopt it's will and become dependent upon it. Actors can be: indivuals, technology, standards, organizations etc.
2. Actor Network: a heterogeneous network of aligned interests , or alignments/translations are underway
3. Translation: the process of creating an aligned network. It is helpful to focus on separate actors and separate translations in different parts of the network.
4. Inscription: A process of creating technical artefacts that would ensure the protection of an actor's interests.
5. Irreversibility: The degree to which it is subsequently impossible to return to a point where alternative possibilities exist.
6. Black box: an immutable inscription/translation has occurred and a part of the network which is stabilised can be collapsed into a Black box which does not need to be delved into. The Black box can be viewed as a sum of the original actors that are black-boxed into it. Irreversibility has occurred.

Central to ANT is the enrolment of actors to courses of action that come about by introducing technical actors into the network which then influence the alignment of

interests in the network. Inscriptions can be weak or strong – and may differ in regards to different actors. Strong inscriptions result in irreversibility. In picturing the groupware tool as an actor/actant one may attribute humanlike abilities, limitations and intentions to the technology. This can be a fruitful approach and analogy of technology as it allows us to endow the technology with various degrees of different qualities – much like each of us do with different people. The affordance of the technology-actant will be relative to and determined, by each separate actor's understanding of the other actors/actants. ANT allows us in other words to take social construction seriously in our understanding of the role of technology, without giving us detailed guidelines as to what aspects of technology should or could be considered. Our experience with humans should provide us with an ample vocabulary to understanding and describing the actant both in regard to inscribed motives and functionality. Only real world-situations can define the role of technology for various people in various settings – and people can redefine these roles by new inscriptions and translations.

Overall ANT focuses on the processes which result in change and the role of the artefacts as well as humans within these processes. The processes are viewed as networks of action. ANT can be used to attempt to lift focus from the local engineering aspects of making things work to the fact that human motivations and politics, as well as organizational settings are an equally important aspect of technological success.

Conclusion

Our claim is that interpretive research can help computer scientists to understand human thought and action in social and organizational contexts; it has the potential to produce deep insights into computer science including the management of information systems, information systems development and software engineering.

We have briefly discussed case study research as a qualitative method, where the purpose of which is to try to understand, or interpret, phenomena in terms of the subjective meanings people bring to them (Denzin, 1994). In addition we have described two social theories for interpretation; Actor Network Theory (ANT) and Activity Theory (AT). The

strength of ANT is the simplicity of concepts and the explicit description of technology as a carrier of inscriptions that influence our actions and choices. AT looks more closely at work and interaction in particular. AT also gives status to technology and artefacts in putting them on the same level as rules, laws and division of labour.

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