84. A Cultural-Historical Activity Theory Approach to Users, Usability and Usefulness

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

Abstract
This paper takes an historical overview of the field of Human-Computer Interaction. It describes how the cognitive psychology emphasis on user involvement in systems development of the 1980s reached its limit by the early 1990s. At this point the focus shifted onto support for the tasks of users using computer-based systems in real contexts, a focus that ideally suits the mobile, ubiquitous and social technologies of the new millennium. The Cultural-Historical Activity Theory provides an appropriate framework for understanding this phenomenon and is adopted in this paper to present the work, over a seven year period, of a usability laboratory grounded in Activity Theory principles.

Keywords: Cultural Historical Activity Theory, Human-Computer Interaction, Usability Testing.

Introduction

An historical overview of the field of Human-Computer Interaction (HCI) shows that it is a rapidly changing field. The 'computer' that was around in the 1980s is very different from the multitude of digital devices and applications we now have and these have radically changed the way all of us live and work. There is still a need to design the devices and applications we use to ensure that they are usable and useful so that one of the main HCI functions, usability testing, is still important. It must however adapt to the changes, not only of the technologies themselves but also the changing human work and social aspects of their use. A critical point in the history of HCI came in the early 1990s when the focus of HCI shifted from the individual sitting at the keyboard in front of a monitor into support for the tasks of users using computer-based systems in real contexts. This focus continues to adapt to the mobile, ubiquitous and social technologies of the new millennium.

In this paper the Cultural-Historical Activity Theory is presented as an appropriate framework for understanding this phenomenon. Relevant aspects of the theory, and then its application to HCI, are illustrated by the work, over a seven year period, of a usability laboratory grounded in activity theory principles.

Background

The field of Human-Computer Interaction emerged in the 1980s. This decade introduced the technical capability for personal computing with concepts of usability and user-centred design (see the seminal work of Shackel 1991, Nielsen 1989, and Norman 1986, 1988). Initially, a coming together of cognitive psychologist and computer scientists built up momentum for the cause of the user. This stimulated the birth of the CHI conferences in the Americas and the INTERACT conferences in Europe followed by others world-wide and HCI related journals. The best-selling books of Norman and Draper (1986) and Norman (1988) were particularly successful in evangelizing the message of HCI for early and constant focus on users when designing and building information systems. This went hand-in hand

with a growth in the numbers of usability professionals, usability laboratories and participatory design development methodologies.

In parallel with the rise of HCI, and predominantly independently of it, Information Systems (IS) researchers adopted the concepts of perceived ease of use and perceived usefulness from Davis's work (1989) on the technology acceptance model (TAM). Rather than the individual user and the computer as partners in an interchange of information, the IS focus was more global on understanding how to develop acceptable technological systems that would make the work of people and organisations more efficient and effective. There was scant attention paid to notions of usability testing during system's development, particularly in house. While there were some practices of including users in the final testing phase, this was usually too late to change any fundamental usability design faults.

The 1990s saw a second, 'post-cognitivist' wave of HCI following the publication of a collection of papers, known as the 'Kittle House Manefesto'(Carroll 1991), put together at a meeting of some of the top researchers in the area. This set of writings provides insight into the reasons why Activity Theory has appealed to researchers into HCI (Carroll 1991). Many authors in this collective work proposed models indicating that the cognitive science approach to HCI had been stretched to its limits. Carroll et al (1991), for example, introduced the concept of the task-artefact cycle setting the scene for the concept of the computer as a tool rather than an information processor on the same level as the human. Norman (1991) described the notion of the cognitive artefacts and claimed that the 'interface' of most relevance was not between the human and computer but between the human with computer and the task. Bannon and Bodker (1991) talked about going 'beyond' or 'through' the interface to observe the artefact in use.

Also in the 1990s, a series of East-West HCI conferences were held in Moscow and St Petersburg during the break up of the Soviet Union and the opening up of Russia to the West. These conferences brought together cognitive psychologists of the West with Russian psychologist who were predominantly Activity Theorists. Kaptelinin and Nardi (2003) articulated the similarities and differences between some of the leading theoretical perspectives proposed as candidate theoretical foundations for 'second-wave' HCI: distributed cognition, actor-network theory, language/action approaches and, particularly, Activity Theory.

The 1990s saw an exponential increase in the use of the Internet, giving rise to a global economy and an interconnected social reality. This laid the foundation for a new civil digital culture which has taken hold in the current millennium, becoming more ubiquitous and mobile with converging wireless devices. The so-called 'social' or 'conversational' technologies are providing unprecedented opportunities for everyday civil user activities with low cost, intuitive functionality and connectivity. They are presenting new opportunities as well as challenges for HCI research and practice. We believe that Activity Theory is becoming increasing relevant in this context.

Activity a more Holistic and Dynamic Unit of Analysis

The concept of *activity* comes from the Cultural-Historical Activity Theory, referred to in the main as simply Activity Theory (see Leontiev 1981). The Cultural-Historical Activity Theory is a social-psychological theory that has its roots in the work of the Russian psychologist Vygotsky during the first half of the 20th century. Vygotsky's important insight into the dynamics of consciousness was that it is essentially subjective and shaped by the history of

each individual's social and cultural experience (Vygotsky 1978). In addition, Vygotsky saw human activity as quite distinct from that of non-human entities in that it is mediated by tools, the most significant of which is language. Vygotsky's work was continued by others, amongst them Leontiev who developed a conceptual framework for a complete theory of human activity (Leontiev 1981). Essentially, Vygotsky (1978) defined human *activity* as a dialectic relationship between *subject* and *object*, i.e. a person working at something. 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*. According to Leontiev (1981), *activity* is a system that has structure, its own internal transitions and transformations, and its own development.

Vygotsky (1978) also proposed an 'instrumented' structure of 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*. Vygotsky also believed that tools play a mediating role in all human activities and mental processes which can only be understood in terms of the tools and signs that mediate them.

Activity Theory provides researchers with a holistic explanation and framework for all the meaningful things people do. It provides a unit of analysis, *activity*, which is the dialectic relationship between *subject* and *object* where the *subject* is the person, or people, engaged in the doing and the *object* in the sense of 'the object of the exercise' encapsulates the purpose and motives of doing. Activities can have individual or collective subjects, i.e. groups or teams of people engaged in particular purposeful work. A different subject or a different object means a different activity. Moreover the dynamic dialectic relationship between subject and object is both subjective and objective. Development of the activity occurs in both the subject and object through interaction and practice so that the dialectic relationship between subject and object extends to one between thinking, learning and doing.

To be able to analyse complex interactions and relationships, Engeström (1987) proposed a research framework with the object-oriented, tool mediated, and culturally mediated human activity system as the *unit of analysis*. This is represented in the triangle shown in Figure 1 which has been widely used in social science research over the last two decades (Hasan 2001). Here the core of an *activity* across the middle of the triangle is the dialectic relationship between *subject* (human) and *object* (purpose). The *subject-object relationship* which defines the *activity* is mediated by *tools* and *community*. Tools which mediate activities can be physical, i.e. technical or psychological such as language, ideas and business models. 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 communities behaves and is organised. This is particularly powerful when the tools are computer-based (Kaptelinen 1996). Influenced by the Scandinavian tradition, Engeström (1987) proposed that the formal, or informal, rules and division of labour of the community, in which the activity occurs, also dynamically mediate the subject-object relationship. 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) 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 motive for change and development.

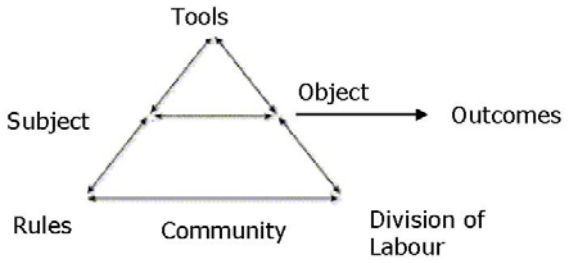

Figure 1. The subject-object relationship, which defines an activity, is mediated by tools and community through rules and division of labour. The subject may be individual or collective and outcomes of the activity are distinct from its object/purpose.

Engestrom's popular triangular representation of an activity, as shown in Figure 1, is widely used as the framework for any activity theory analysis. Understanding grows through the 'always active subject' (ie people continually change/grow as they learn through the life of an activity). There is thus a synthesis of learning and doing at the core of human activity that underpins the current concept of knowledge work.

An activity is a high level unit of analysis that is related to purpose and motives and is culturally and historically situated (ie take place in context). *Activities* are performed by sets of *actions*, which relate to a specific goal or *objective* (NOT objects) but are not meaningful in themselves, only in their contribution to the activity. Different sets of actions can be used to conduct the same activity. Under certain *circumstances* actions can be automated to *operations,* many of which are incorporated in the design of ICT systems. *Activities – actions – operations* form a dynamic hierarchy (Leontiev 1981). This hierarchy (Figure 2) is dynamic and one of the most widely used concepts of the theory.

Activity - Motive

Action - Goal

Operation - Conditions (Task)

Figure 2 The Hierarchical Structure of Activity according to Leontiev (1981)

According to Verenikina (2003), Vygotsky recognised that the distance between doing something independently and with the help of another indicated stages of development, do not necessarily coincide in all people. In this way he regarded an instructors 'teaching' of a student not just as a source of information to be assimilated but as a lever with which the students thought, with its structural characteristics, is shifted from level to level. In other words learning in the zone of proximal development (ZPD) refers to performing a range of tasks that the person cannot yet handle alone but can accomplish with the help of instructors or more capable peers. This would also apply to usability tests where a facilitator could extend novice users into their ZPD so that their behaviour was more like experts

Activity Theory appeals to HCI researchers and practitioners because of its central concept of tool mediation whereby computers can be viewed as special tools used by humans to perform activities. Where the situation involves complex problems with changing power structures

and locus of decision-making, the activity theory framework is appropriate. Bodker (1991) used this approach when studying the blurring of the design and use activities in situations which involved the design and use of information structures.

Fundamentally, usability is about the fit between activities and the tools used to carry them out. The interaction between humans and computers is continually evolving through the development and new uses of computer tools. This interaction occurs in a socio-cultural context and cannot be divorced from it. Activity Theory provides a framework for studying this interaction through the concept of tool mediation. According to Carroll (1991) Activity Theory "directs analysis on persons acting in contexts, but at a higher level of description, seeking to understand extended sequences of action in terms of long-term human motives" (p.7). This has certain implications for usability testing.

Usability Testing

Traditional usability testing methods primarily involve observations of individuals using computers and interacting with software or information systems prototypes in especially equipped laboratories or less formal settings. The metrics employed in this traditional usability testing process relate to mainly to human cognitive abilities such as memory, perception and motor skills, while types of statistical measurements include time taken to complete tasks, error-rates, ease of learning and perceived ease of use. These methods are deemed suitable for transaction processing and similar operational systems; however, they fail to account for factors critical to the success of leading edge technology in current times.

Limitations of this frequently employed approach to usability testing are evident in the lack of methods that effectively evaluate:

- the ability of an system to support user tasks involving complex knowledge sharing of decision-making;
- how users will perform in the future when they graduate from novice to experienced use;
- how well a system supports activities involving groups of users;
- how the use of a system is affected by the environment and context of use.

Traditional usability testing has been neglectful of the purpose and context in which people perform the activities that involve interaction with computer-based systems. In a sterile usability testing laboratory, the focus has been primarily on the interaction of a user, often a surrogate, with an interface regardless of the role the system plays in the larger context. This is due to the difficulty associated with defining a context and emulating typical user motives in a laboratory setting. The assumption that a laboratory setting, devoid of practical meaning, will produce generalisable results is dubious because the analysis will not actually be applicable to any single meaningful context in the human experience (Carroll et al 1991).

Applying an activity theory framework to usability testing makes 'activity' the focus and unit of analysis as far as is possible in a laboratory situation. This means that in planning a usability test, the user activities are identified by their object, which includes purpose and motive, and the system is seen only as a tool in this activity not the main focus. Also the user's context is simulated wherever possible. This may mean that serving the user's purpose and enabling to complete tasks is more important than many of the traditional usability metrics.

The Activity Theory Usability Laboratory

The Activity Theory Usability Laboratory (ATUL) is a university research and commercial unit. It was formally established in October 2000 to carry out usability testing of software prototypes and information systems (IS) that support practical human activities, either as individuals or in groups. ATUL was set up to conduct research into Human Computer Interaction, Activity Theory and Knowledge Management as well as for practical usability testing of systems using the methods derived from our research. ATUL also offers an additional selection of innovative services designed to improve the way people and organisations use information and obtain the most benefit from modern technology. The research conducted at ATUL employs an innovative approach to usability evaluation particularly suited to highly interactive and complex systems. This approach is the direct outcome of original research into the application of Activity Theory to HCI.

ATUL's philosophy is to adopt *activity,* as defined by Activity Theory, as the unit of analysis in everything it does. It aims to eliminate problems in usability testing, such as those discussed previously, where typical testing of standard interface elements has failed to uncover less easily measured factors. It provides a usability evaluation facility and a host of activity theory based assessment procedures and methods that allow researchers to capture and analyse group activities mediated by computer tools in a specific context of use by

- providing rich feedback on the usability of systems supporting complex group activities,
- allowing facilitators to work with users to simulate experienced use of the system,
- recording the activities and interaction of groups using the system as a mediating tool, and
- simulating a natural user environment and context of use.

The activity theory view of usability testing takes a realistic and 'hands on' approach, which identifies the purpose of a business's computer system or web-site and tests it in a situation that simulates the typical real-life activities of the users.

ATUL setup

ATUL is housed in two adjacent rooms have been set up as separate testing and observation areas. The testing room has been set up to simulate a typical office environment, however, the layout is flexible to accommodate any type of scenario or context. Two cameras have been unobtrusively positioned at selected points from which the activities taking place in the room can be captured. One camera is focused on the user or participant, capturing facial expressions, hand movements on the mouse, keyboard and related documents, and any sound or verbal comments made by the users, while the other camera provides a wide shot angle of the entire room in simulating group activities. In the original configuration, the associated computer screen images and actions are captured using a scan converter to create a synchronised high-quality video image that is recorded. This set up permits either real-time viewing and discussion or delayed analysis of the recorded sessions. The video input from the scan converter is fed through a quad-box in the control room, allowing synchronised multiple views on the TV screen at once. The observer also has the ability to add his/her comments using a computer in the control room and display those on the TV screen simultaneously through a second scan converter. A diagram of the original equipment configuration and lab layout are shown in Figures 3 and 4 respectively.

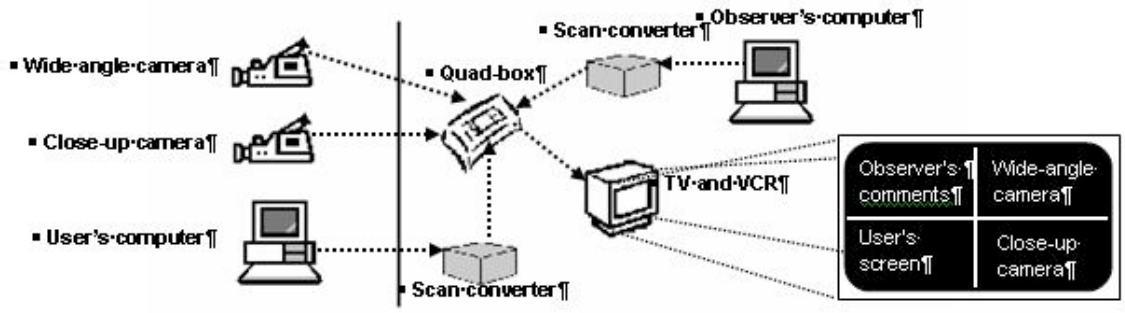

Figure 3: ATUL Equipment Configuration

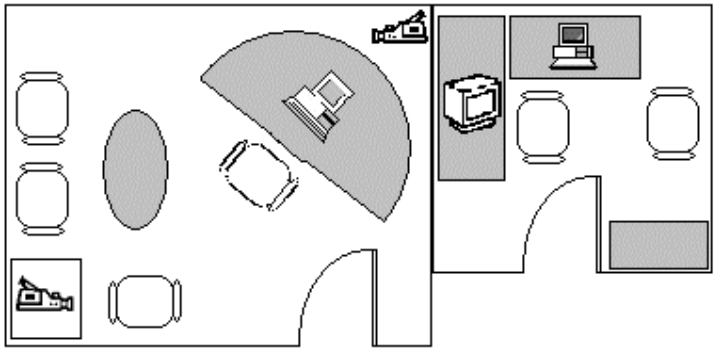

Figure 4: ATUL Layout

As digital devices have improved and become more affordable ATUL has acquired digital video screen capture software, Camtasia, and associated digital cameras and recording equipment to add flexibility to the original set up. A workable set of equipment is also portable so can be taken to a client's site where necessary.

ATUL Procedures

Firmly based in the activity theory framework the procedures followed in ATUL usability testing are:

1. **Establish test goals:** Testers consult with the client to establish the reasons for the test and what form of outcomes the client expects to accomplish.
2. **Establish the system purpose:** The clients and/or owners are interviewed to determine the business goals that the system is designed to achieve.
3. **Information Gathering:** The information from stages 1 and 2 is used to create a questionnaire for interviewing the user after the test.
4. **Identify User Characteristics:** Who is going to use the system? The range of potential users of the system is identified. This could vary from novice users to experts in the field.
5. **Identify User Activities**: Typical user activities are identified including the presumed needs and goals in using the system. What would people want to use the system for? What information would users need to find out?

6. **Devise Test Scenario(s):** Typical scenarios of use are produced at this stage to enable the usability testing to proceed. Tests can be more or less structured as required.
7. **Select Test Subjects:** A number of suitable people are chosen as subjects to play the role of users. Subjects are reassured that it is the system, not themselves, that is being evaluated. An expert facilitator may be needed and their role to prompt subjects during the tests is explained to the subjects.
8. **Conduct the Usability Test:** In the usability laboratory, the scenario is explained and given to the subject who then proceeds to carry out the tasks. Simultaneous recordings are made of the whole room, the computer screen, together with the user's facial expressions, eye and hands movements. Audio is also recorded. If a facilitator is present they will keep the user on the task, by asking general, encouraging questions such as 'Are there any other ways to do that?' 'Where else could you look for it?' The post-test interview, using the questionnaire from stage 3, is also recorded.
9. **Analyse the test records:** The captured recording of the usability test is reviewed by usability experts in the context of the test goals and system purpose.
10. **Write the client report:** A comprehensive report is provided to the client explaining the test results and suggestions for improvement to enhance the system and productivity.

Illustrative Examples of work at ATUL

As mentioned previously, ATUL has been operating as a research, training and commercial usability laboratory for seven years. In this time, each test was designed and planned starting with the identification of the main activities of interest to the users and the owners of the system being tested. It was important to maintain the focus at the level of activity as shown in the hierarchy of Figure 2 and not the level of goal oriented actions. The latter is probably where most other usability testing regimes focus. Some brief examples of ATUL projects are:

Facilitation to cross the ZPD

While several of the websites tested at ATUL are public sites so that users may well be considered as novices, one particular site design tested was to be part of an organisational Intranet. In this case, once the site was in place it would be used regularly and it would be more appropriate to test for expert rather than casual or novice use. However as the site was not yet released no experts were available and training before testing would have been too time consuming. Based on the activity theory concept of ZPD, a facilitator was used in each test session to 'instruct the subject whenever it was felt that they were inhibited by problems that would be overcome with regular use. In other words, although all subjects were novice users of the system, the facilitator moved them across their ZPD so that they behaved as experts as was more appropriate for this test.

Portable ATUL

In some cases working with system belonging to the Police Force or Department of Defence, the systems to be tested could not be set up in the laboratory for security reasons. In this case portable gear was taken to the site and the tests were undertaken there. This had the advantage of retaining a much more realistic context with interruptions, noise etc.

Group Activities

In several tests there were a group of users at each test. This included:

- young children in the same room playing computer games on two different computers
- the co-design by two IT student of data-base specifications using a shared online whiteboard on computers in two different rooms.
- Groups as surrogate families of hospitals patients testing a Public Health Information website.
- Military personnel playing a team building simulation, communicating via online chat.

In each case the flexibility of the setup which enabled the testers to focus on user activities rather than user interaction with the technology meant that the results of the tests were much more relevant and helpful to the client.

Conclusion

It is clear as presented in this paper that both the technology itself, together with the field of Human-Computer Interaction, have changed since the early days of the 1980s when cognitive psychology and computer science came together. With the shift in focus in the 1990s to the tasks of users using computer-based systems in real contexts, HCI has looked to more holistic theories and frameworks to support this shift. Activity Theory, as demonstrated by its successful application at ATUL, has much to offer the new HCI and provides a direction for usability testing that can adapt to the changing world of work supported by technological systems of all sorts.

Technologically base systems are now mobile, ubiquitous and social with the convergence of what were once quite separate application and devices. This is an exciting time for the field of HCI if it can meet the challenge of adapting to new emerging digital culture. The Cultural-Historical Activity Theory should continue to provide an appropriate framework for understanding these phenomena, enabling HCI researchers and practitioners to follow current trends and be prepared for future developments.

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