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## Towards An Activity Theory Perspective on Mobile Information Systems

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### Abstract

*Mobile technology allows the potential to extend an organization's information system and therefore information access and collaboration outside the normal boundaries set by the traditional office, affording access to information from remote locations. It is therefore puzzling that with the large capital expenditure for research and development into mobile devices that their adoption and use does not necessarily reflect returns in the same order of magnitude. This confusion is compounded further considering the large quantum of research that has been already undertaken in the area of technology diffusion. This paper reflects on the existing work practices, which are often ignored in the implementation of mobile devices contributing to issues with new system adoption. We attempt to highlight the factors that affect adoptability of mobile technology devices through the use of Activity Theory.*

### Keywords

Mobile Technology, Adoption, Diffusion, Activity Theory.

### INTRODUCTION

Conventional workspaces such as the office have evolved over time as a result of the work practices that human beings have developed. Far more than a physical space, the office represents a central coordination point for work, affording information access and collaboration. Malone and Crowston (1994) describe coordination as “managing dependencies between activities” and that for coordination to be able to take place, the processes of group decision-making and communication are essential. The traditional office model facilitates these processes through face-to-face access to colleagues (through the virtue of existing in the same vicinity) and information (such as pertinent documents) upon which an informed decision can be made. These central coordination points have in more recent times been augmented by the use of technologies such as the Internet and email, that allow for the disbursement of traditional centres to “off-site” and home offices. That is, workers have effectively replicated the centre of coordination such as the typical office to a place of convenience, such as the home. The replication of the office is not unusual in modern work practice, illustrated by the Australian Bureau of Statistics which reported in 2000, that approximately 287,500 employees had negotiated with their employer to work some of their time from home.

The next logical of the workspace is the movement of the centre of coordination, for some work types, from a traditional office set up (which is what the home office is) to the point of work itself, particularly for a worker who

is required to be mobile. A mobile information system would provide information access on demand anywhere, any time in which wireless access is available. The development of mobile tools such as the laptop and Personal Digital Assistant (PDA) and the evolution of wireless protocols to handle digital transmissions have reached a stage of development that this could become a reality.

Surprisingly, the diffusion of such technologies has been far from spectacular, with many documented cases of mobile technology adoption failure, see for example Luff and Heath (1998), and Sellen and Harper (2002). Many researchers have continued to examine practices of innovation diffusion in order to understand and develop frameworks for the adoption of technology. The well-recognised framework of Rogers (1983), proposes that the diffusion of innovation is heavily dependent upon such elements as communication, time and the change agent. The theory outlines a broadly linear diffusion process moving through the following stages: Knowledge (exposure to its existence, and understanding of its functions); Persuasion (the forming of a favourable attitude to it); Decision (commitment to its adoption); Implementation (putting it to use); and Confirmation (reinforcement based on positive outcomes from it). Furthermore the theory describes the basic characteristics of an innovation and the different categories of adopters (users) through which an innovation diffuses.

Rogers (1983) theory has been widely applied to a range of industries and innovations, however, remains steadfastly at the sociological level of analysis, i.e. how an innovation diffuses through society. Our interest in this paper is to understand the nature of adoption at lower levels of social system resolution, i.e. that of the individual workplace. To do this we propose the use of Activity Theory as a framework for identifying and understanding issues in specific work contexts and the process of developing mobile technology systems to replace existing inefficient systems. We will argue that the use of Activity Theory provides developers with an additional perspective in informing the development and implementation process so as to increase the possibility of success. As such it is not an alternative framework we are offering, rather an addition to existing theories such as that proposed by Rogers. If the technology to be introduced is well understood, the source and receiver are homophilous (that is “One of the obvious principles of human communication is that the transfer of ideas occurs most frequently between a source and receiver who are alike... When homophily is present in communication, therefore, interaction is likely to be more rewarding to both the source and receiver.” (Rogers 1983)) and the outcomes bring relative advantage over the old system, then one would expect a positive response to that technology. This is not necessarily always the case. To demonstrate this we will examine a case study: a pilot scheme from a health services context aimed at introducing wireless technology to a hospital ward. By examining the pilot scheme through the lens of Activity theory, we will argue that it is possible to uncover several general issues with regard to mobile technology adoption and work practices that are not predicted through other frameworks.

In the next section of the paper we will briefly describe the basic concepts underpinning Activity Theory. This will be followed by the methodology and a description of the case study. Lastly we will discuss our findings in relation to Activity Theory. It should be noted that Activity Theory is a complex philosophy and due to the space restrictions placed upon this paper, only the basic principles will be highlighted in order to make a logical argument regarding implementation processes for mobile device adoption and the use of the theory.

## ACTIVITY THEORY

“The cultural-historical theory of activity was initiated by a group of revolutionary Russian psychologists in the 1920s and 1930s” Specifically the theory is credited to Lev Vygotsky, A.N. Leont’ev and A.R. Luria. The underlying philosophy of this theory was aimed at explaining human behavior / activity. Kuutti describes it as “a philosophical and cross-disciplinary framework for studying different forms of human practices as developed processes, with both individual and social levels interlinked at the same time.”

Within the theory, the analysis of human practice is done on the basis of activity. An activity is depicted as humans’ “doing”, which is described broadly by Nardi (1998) to include “things like speaking, mediating, remembering, as well as activities more centred on the body and its movements. A *Subject* undertakes some activity in order to achieve an *Object* (see diagram 1 below). This *Object* is the theoretical result that the *Subject* is trying to fulfill however in undertaking the activity, the result in mind and the actual *Outcome* may differ.

An activity is controlled by the motive of the *Subject* towards the *Object* with the underlying reason not always being clear. For example, in building a house, a carpenter may start assembling the timber frame at a location other than where the building will eventually stand. To the untrained person this would seem illogical however prefabricating the timber frame of a house is often undertaken while the foundations of the building is taking place. This means that as soon as the foundations of the building are complete the frames can be delivered and fixed into place, saving a substantial amount of time for the construction process. The house building example illustrates another characteristic of Activity Theory; that being an activity is composed of one or more *Actions*. An *Action* component, unlike an activity is goal directed. For example, the construction of the frames or the building of the foundations. *Actions* can be composed of other actions as well as automatic processes, or *Operations*. Using the building context, an illustration of an *Operation* is the hammering in of a nail by a carpenter. This work does not require conscious effort by a skilled carpenter.

It is interesting to note that Polanyi (1958) in his theory of knowledge also makes the same distinction, indeed, using the same example of hammering a nail to explain it. Polanyi concentrates more on the complementary relationship between what he terms focal knowledge, explicit knowledge and tacit knowledge (Polanyi 1967), a point often lost in knowledge management literature. Focal knowledge refers to knowledge about an object or phenomenon that is in focus. In this activity it is the nail, which is in the individual's focus. Tacit knowledge refers to knowledge used to manipulate or relate to the object of the focal knowledge, using the above example, this would be holding and moving the hammer onto the nail. Polanyi's point is that in this process the individual would not appear to be conscious of the motion of hammering, the hammering is not an object of attention. He suggests that we have a "subsidiary awareness" (1958) of the hammer. It is likely that the parallels between Polanyi's work and the collection of concepts within Activity Theory could produce valuable insights about the nature of action however such an exploration is beyond the scope of this paper.

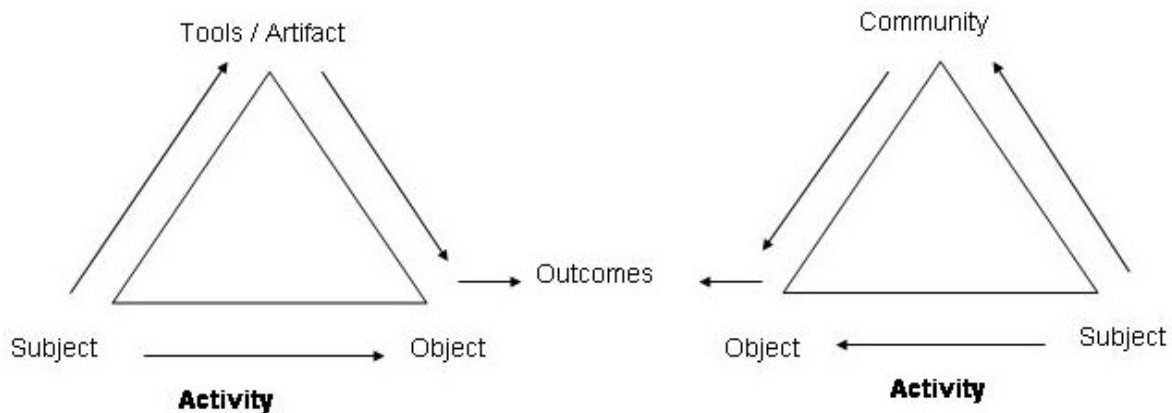


Figure 1: Mediated Relationships in Activity Theory

As can be seen in Figure 1 above, the way in which the *Subject* approaches the activity in order to achieve the *Object* is mediated through *Tools* (also described as artifacts). *Tools* can take various forms depending upon the context of the study, for example they may range from instruments, signs, procedures, machines, language, methods, laws, forms of work organization. It is evident that "mobile technology" could be substituted as the tool that is mediating the activity. That is, an introduced piece of mobile technology will mediate the way in which the work activity is undertaken.

Activity Theory centers on the concept that the way humans undertake an activity is influenced by the environment around them and their ability to develop an understanding based upon previous experiences in order to make logical actions. This is important to consider when developing a new technology-based system with which humans will

interact. As opposed to the bits of data, which are easily identifiable and therefore accountable, the “internalized” and informal processes identified in Activity Theory models, are not so obvious. It is argued that the “artifacts themselves have been created and transformed during the development of the activity itself and carry with them a particular culture—a historical residue of that development” (Kuutti 1996). This is an important concept to remember as it indicates that there has been some form of “co-evolution” between the activity and the *Tool*. For a *Tool* to arrive at a point of stability and acceptance there needs to be interaction over time for evolution of both the *Tool* itself and the emergent work practices in using the *Tool*.

The second generation of Activity Theory was initiated by Leont’ev. This second generation of the theory and its associated literature is characterized by a shift towards the view that because individuals are a product of their culture (and artifacts have cultural significance) existing characterizations of the individual subject were a limiting factor to the theory. They therefore proposed that activity is a collective system with the *Subject* being a group striving for a common group objective. Leont’ev (as in Kuutti 1996) describes the collective activity system through the illustration of primeval hunters. The hunters are broken into 2 groups, one group frightens the animals to move from the safety of bushes and the second group catches them. The idea of beating the bushes may seem irrational to observers unless the collective *Object* to catch animals is understood. This leads us to another important factor that mediates the way a *Subject* takes part in their activity, that is, the “Community of Practice”. The *Subject* is influenced in its approach to an activity by the community of practice through *Rules*. *Rules* are the accepted explicit and implicit conventions held by the community and include such examples as standards, formal and informal procedures as well as the social relationship between the *Subject* and the *Community*.

The theory described above will be used as a heuristic to explore the follow case study described below.

## **METHODOLOGY AND SITE DESCRIPTION**

This case study presented in this paper is of a Mobile Hospital Ward involved semi-structured interviews with key personnel in a ward of a major Australian hospital where the use of mobile devices was being trialed. A total of 8 interviews were conducted, including 3 doctors, 2 nursing staff, an administration clerk stationed at the nursing station, the project manager for the implementation and the chief information officer for the hospital. Interviews ranged from 10 minutes to 1 hour in length depending upon the availability of the participants and the degree of involvement they had with the pilot scheme. Observation of doctors conducting their ward rounds was also undertaken in an attempt to understand the overall process through which the patient records were used. Results of the interviews and observations were then metaphorically mapped to the activity theory framework in order to surface the operation of the key relationships involved.

### **Hospital Case Study: The mobile ward system**

The Mobile Hospital Ward System was developed to allow access to information in the online patient records used by doctors on their ward rounds. The previous system required doctors to download information regarding a patient from the patient records of different departments (such as radiology or pathology) when appropriate. These documents were downloaded early in the morning to create a paper-based hard copy for doctors to use when conducting their ward rounds. A number of collaborators could contribute to the patient record including several doctors (various specialists as well as the attending doctor), nurses, different medical departments as well as other medical consultants such as physiotherapists.

It is important to note that these collaborators (for example specialists from different departments) maintained data stores where each was able to update their information in the patient record as results came to hand. This created a problem, in that if an update was made whilst a ward round was in progress, the doctor would not have access to that information until the end of the round, which could take up to 3 to 4 hours. The potential is therefore created for the doctor to make an incorrect / misguided diagnosis in the absence of the most up to date information. For example, if a test were ordered but the results had not been put on the system at the time of printing out the patient record, then information vital to the health of a patient might be missed or even be a cause of a misdiagnosis. Compounding this issue further, the metaphorical office (or coordination point) for the doctor existed in more than

one place. Doctors utilized nursing stations as one office (coordination point), where they were able to access colleagues (for example formal and informal discussions about patient cases) and information from the terminals provided. A second metaphorical office existed at the patient's bedside where the records of individual patients were stored in paper form, held in folders.

To address this issue, the case study hospital began trialing a wireless information system that would allow doctors to access the up-to-date information (real time) whilst on their rounds. The system included a wireless enabled Tablet PC, that allowed the user to write their reports and access data using a sensor pen. The Tablet as provided, included the availability of a keyboard. IEEE 802.11b was used as the protocol for data transfer to allow access to the patient records. The same graphical user interface as the ward's desktop PC appeared on the tablet screen. As such the interface was exactly the same as the one used to download patient information.

The development of the system included a long consultation process with the users. Further, a senior doctor who worked on the trial ward was heavily involved with the development and implementation of the new mobile system. Training sessions were also organized however these were on a voluntary basis and no doctors attended. It is interesting to note that the system did not at the time of the interview, allow doctors to update the patient records and this process remained paper-based. The hospitals CIO suggested "...changes to the work process could only be achieved in small steps...", (Hospital CIO) and as such functionality was purposefully limited on the pilot system.

## **FINDINGS: HOSPITAL CASE STUDY**

The overwhelming outcome of the trial was an almost total lack of adoption by users of the new system. Although the system had been created in consultation with its users, only 1 out of the 4 doctors interviewed had actually used it, and the one who had only used it once. The doctors continued to use the paper based system that they were used to and as a consequence of the lack of support shown by users the trial has since been suspended.

Through the interviews a number of general issues were exposed that could be seen to contribute to this unfortunate outcome. The first issue was security of the equipment. "Unless nailed down any piece of equipment will walk out of here (be stolen)." (Doctor 3) This point contributed significantly to the poor success / adoption of the system, as neither nurses or doctors felt prepared to take responsibility for the Tablets, if one was stolen during their round. Furthermore access to the laptop was restricted to the doctors. One doctor stated that "if everyone else (administration, nurses etc) has access to the laptop then the system won't be available for our use (i.e. by the doctors)" (Doctor 2). As such, even though the doctors chose not to use the system, they didn't allow anyone else to either. This point highlights a class division that appeared to exist between the doctors, nursing and administration staff. It is important to note that the system could also have been useful to nursing staff in their rounds, and in fact nurses felt that the system was generally a good idea. As one nurse observed "I would use it if I didn't have to be responsible for it ... but now it just stays locked in the cupboard...".

The reason for the lack of adoption by the doctors was not immediately obvious. Having tried the new system (only once), one doctor returned to the old paper based system because he felt "more comfortable with it" (Doctor 3). Theoretically, however, the system was not much different to that which they already used. The doctors were already familiar with the interface used as they used the exact same interface on desktop computers to download the information for the paper-based system. Additionally, Doctor 3 had a personal laptop which he used in private practice. In the next section, we will explore this observation further.

## **DISCUSSION**

Most contemporary developers in the IT field (particularly in the HCI area) advocate the participation of users in order to achieve a successful project. These observations have in part led to the development of design methodologies such as extreme programming and participatory design. The association of the senior ward doctor seems to also indicate that Roger's homophilous requirement had been met. That is, the communication sender and the receiver (change agent and the other doctors on the ward) have similar "attributes, such as beliefs, values,

education, social status, and the like.” (Rogers 1983). In reviewing the hospital pilot scheme we note that the user (in the form of a senior doctor on the ward) formed part of the development and implementation team yet the system’s adoption failed.

A view of the case study from the perspective of Activity Theory reveals some of the reasons why the system was ‘uncomfortable’. The model in the mind of the developers was based around the *Object* of making a particular activity more efficient, in this case the use of the patient record system. In this context the Tablet is assumed to be the *Tool*. In adapting the software for use on the Tablet this assumption is logical and leads to a system that satisfies an *Object*. The question arises however, about what exactly the *Object* was or could be. In our review of the pilot scheme, it was clear that all activities in relation to the implementation of the Tablet were directed at the Tablet (i.e. the technology), rather than the broader activity of accessing the patient records and all the socio-technical processes involved in this activity. When one changes perspective, however, to assume that the actual activity involved in this pilot scheme was a change of work practice (rather than a change of tool), the focus of development changes suggesting that the implementation could have been undertaken quite differently.

For example, the work practices of doctors have slowly evolved over many decades and are ingrained through their training. The more ingrained a process is, the more difficult it is to change, regardless of the logic in making the change. The doctor who used the system couldn’t explain why he was more comfortable with the old system – he just was. In an interview with Bergman (2000), Don Norman observes “...the vast majority of people (perhaps 75 to 80%)...don’t want to change their system every six months, not even every year. They want stability. They want a very slow evolution towards improved devices, slow enough so that they can grow with them, learn them, and feel comfortable with them. They want a slow, steady evolution, not these big gigantic changes every six months.”

Activity Theory emphasizes the importance of examining the existing work practices. Detailed observation of the doctors work practices in relation to accessing patient records were undertaken superficially in the development of the new system (through the involvement of the senior ward doctor) and as a consequence important steps in the process were ignored. For example, the doctors habitually read the patient records as they came off the printer, in effect allowing more time to digest the information and consider the implications of the test results. When speaking to patients in most cases the doctors would put the information down on a side bench or the end of the bed so that they could either examine the patient or speak to them in an unencumbered way. Each of these *Actions*, had over time become *Operations* for the doctors, i.e. they were unconscious elements in their overall work process. With the Tablet, they felt less able to do so due to the security risks involved and a perception of fragility. In fact the doctor who did use the Tablet, resorted to wheeling it around the ward in order that he could keep his hands free for the patient consultations (another change to the process). These changes were necessitated in order to compensate for the changed *Operations* involved in the Tablet mediate activity. Observations of the doctors on the ward rounds (old system as well as trialing of the new system) was not undertaken during the development process and therefore informal rules (ways of doing work) such as the above were not accounted for in the new system.

The fact that there was a lack of use by doctors meant that even though they could see the benefits afforded by the mobile system, there remained an element of mystery. Through using the system some familiarity could have been gained and a new emergent approach to the activity could have been identified (even if this is not exactly the use that the designers had in mind). From there the activity and tools could have co-evolved (fine tuning of the actions) and possibly led to a point where (critical mass) acceptance was achieved. This concept reinforces the concept of time in diffusion as described by Rogers (1983). Adoption can only be understood over an extended period of time, not just a short implementation.

The introduction of the Tablet therefore did not just mean a change from using a desktop computer to access patient records to using a mobile laptop type device, it represented change to a multitude of steps throughout the whole process, each step adding to the discomfort of the user and consequently lowering the chance of successful adoption. The way the computer (tool) was used represented a totally different way in which work was carried out. Previous processes that were more or less *Operations* became new actions meaning the activity, actually became more complex for the subject.

## CONCLUSION

This paper described research conducted on a pilot scheme, which changed the existing information system to a mobile (real time) system. It explores the value of applying concepts from Activity Theory to the study of these systems from a human development perspective. We would argue that the theory adds to previous research into technology diffusion and further sheds light on the complexity involved in technology mediated changes to work practices and indeed the complexity of the work practices themselves. In the case of the Mobile Ward described, the collection of concepts within Activity Theory provided a useful frame for unpacking the various dimensions of the change process from different perspectives. It also provided a practical perspective on how the development process could have unfolded. Specifically, the theory suggests that as part of the design process, the *Subject's* motives as well as the broader *Object* should be considered. Furthermore, it is important to consider those elements of the existing activity that exist as *Operations* or that have become unconscious. These elements will become sources of resistance as they move from being *Operations* to *Actions* in the new scheme. Any movement of this kind will be associated with discomfort for the users and consequently receive limited support without the aid of other environmental cues.

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