Activity Support with Mobile Technology: The Path to Adoption

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Abstract

The use of mobile technology by individuals as well as in the commercial world is ever increasing. Large amounts of resources are used in the development of mobile technology with little idea of whether a particular tool will be successfully adopted by industry (and the individual working in that industry) or not. This paper uses activity theory to model the adoption of mobile technology in two case studies, both of which use mobile devices in commercial applications for the purpose of efficiency gains. The first case study makes use of wireless technology and personal digital assistants (PDA) in a restaurant ordering system while the second involves the use of a laptop with wireless connection in a hospital ward. We model the "before" and "after" activities with the simple triad of subject, object and tool, and use Engeström's hexadic (2001, p59) model to elucidate the influence of community, rules and division of labour on the relative success of adaptation in these cases. With this insight we suggest the first steps towards the development of a method for evaluation of a mobile tool in use before large resources are expended on its development.

1. INTRODUCTION

There is an increasing interest in mobile technology, and many of the technical and standards problems related to this technology are gradually being solved. It is not clear, however, in which work or life situations this technology can be usefully employed, and in some cases expensive systems have been introduced only to fall into disuse. The data concerning the two cases discussed here was collected for an earlier study (Er, 2003). In this paper we undertake a secondary analysis using Activity Theory, to help us understand some of the contextual factors affecting the success of mobile technology projects.

2. MODELLING CHANGES TO COLLABORATIVE ACTIVITIES

In its simplest form Activity Theory deals with the interaction of subject and object mediated through an artifact or artifacts (Kuutti, 1996, p26). The subject (a person or group of persons) would appear to initiate the activity, using the artifacts (tools) to produce or achieve the object in accordance with their (the subject's) intentions. But the unit of analysis in Activity Theory is the activity, not its components. Reciprocal interaction amongst these "components" means that the subject is themselves changed by the use of the artifacts and by the achievement (or otherwise) of the object. As an example we might imagine a performer (subject) who magically produces a live dove (object). The artifacts used are a silk scarf and a knowledge of magic (and, if we are unbelievers, a dove). Through practice of the knowledge and production of the dove the performer becomes a magician. The outcome of the activity might be audience enjoyment, wonder and possibly a profit for the magician.

Suppose that sometime later we see the same magician performing a similar trick, but this time they turn a pair of nail clippers into a handgun. Perhaps the outcome will be the same as before, perhaps instead there will be audience puzzlement and financial loss for the magician. What might contribute to one or other of these outcomes? All activities take place within (and reciprocally influence) a context, the community. In Activity Theory the relationships of the community to the subject and object are labelled respectively "rules" and "division of labour" (Kuutti, 1996, p28). This distinction seems rather arbitrary and presumably there are also connections between the community and the artifacts, particularly if they are in the form of knowledge (Foucault, 1994). In a static situation the influence of the community may be largely unnoticed, but as the activity changes relationships to the

community come to the fore. In our example a heightened awareness of airport security may influence the audience's understanding of the new performance, and attitudes to magicians undertaking political comment (division of labour) may also have changed. The division of labour within the activity may also change; originally the silk scarf may have been obtained from the audience, but this may not be so easy with nail clippers.

Division of labour within an activity raises the issue of collective subjects. Sometimes authors write as if the subject can be either individual or a group, but is always regarded as singular, "an agent who acts (an individual or collective "subject")" (Bannon, 1997). Sometimes individual subjects are regarded as being "co-ordinated" through membership of a community which is assumed to share a common object orientation. Ellison and McGrath (2001, p150), however, point out that communities are often divided in their motives. The analysis of group activities might be assisted by decomposition. In Activity Theory activities can be decomposed into actions with specific goals and further into operations which are performed more or less subconsciously and conform to a classic stimulus-response model. The difficulty remains that the object of an activity is to some extent a mental construct, the partial internalisation of a need (the desired outcome) as a problem to be solved (Vygotsky, 1978, p37). Whether it makes sense to postulate group mental constructs or group visualisations of problems is a difficult question that haunts all approaches to researching collaborative activity.

The tension between the internal and external aspects of the object of activity signifies the question of the objectivity of models of "an" activity. Are we modelling a generalised activity (a recipe for turning scarves into doves) or are we describing just one magic moment which, because of its context dependence, is never repeatable. Bannon (1997) points out that this dichotomy goes to the foundations of Activity Theory where Soviet scientists had particular difficulty in reconciling the positivist and subjectivist approaches to psychology. Since (in common with much research applying Activity Theory to information systems) this paper uses an interpretivist methodology we will be unable to claim any objectivity for our models.

In the remaining sections we will consider two cases where mobile computing was introduced as a tool to support an existing activity. One case, in a restaurant, was deemed a success, while the other, in a hospital, failed. By modelling these cases using activity theory we will both clarify some of the issues introduced above and will gain some insight into why such developments might succeed or fail.

3. METHODOLOGY

For both cases interviews were conducted with staff that were involved in the development and management of the new technologies, as well as users of the system. The interviews were semi-structured and were analysed informally, based on our knowledge of the industries concerned and of mobile technology. A second round of interviews was also carried out with several of these participants as this analysis revealed new areas of interest for examination. The results of these interviews are first presented in narrative form, then modelled using Activity Theory.

4. SUCCESSFUL CHANGE - THE RESTAURANT

INTRODUCING MOBILE TECHNOLOGY

The Restaurant Mobile Ordering System utilizes mobile PDA technology in order for table staff to take orders for meals in the restaurant and communicate these orders with bar and kitchen staff. Prior to the introduction of the system the traditional restaurant ordering process was employed. The waitress/waiter using paper note pads wrote down client's drink and meal orders. Initially, table staff would record drinks orders from clients and verbally passed these on to bar staff for preparation, before returning to the table with the order. On return, meal orders were taken by table staff and handed to the kitchen staff who would cook the meal. Table staff retained the original order with the kitchen receiving a carbon copy. When orders were ready a bell was rung and table staff would deliver the order to the client. On finishing the meal, the floor staff presented clients with the bill and the payment process took place.

The restaurant owner, in an attempt to improve customer service, decided to replace the hand written order taking process with a wireless network framework, incorporating the use of wireless enabled PDAs for the table staff. *What I really wanted to achieve was improved customer service. The table staff were spending too much time running back and forth between the bar and the kitchen when ideally they should be waiting on the customers. The PDAs mean that they can stay on the floor for a greater percentage of the time* (Restaurant owner, 28/7/03).

The hardware underpinning the system includes: *...wireless enabled PDA's (personal digital assistants) which are used as a replacement to the order pads.* (Restaurant owner, 28/7/03) The PDA's have an interface similar to the menus used by the customers with cascading screens allowing table staff to select the items for consumption, the quantity and any special requests to do with that order. The PDAs also allow orders to be changed at any stage. *The PDAs connect to the restaurant's wireless network through two wireless access points.* (Restaurant developer, 28/7/03) The wireless protocol utilized by this system is IEEE 802.11. This protocol allows connectivity to a *printer located in the kitchen and the till system located at the bar. It also connects to a database server which stores all processed orders.* (Restaurant developer, 28/7/03). The software used on the PDAs was a proprietary package purchased by the restaurant and as such the basis of the system was created from an 'off the shelf' product. That is the base system, prior to adaptation and adoption by the restaurant, had undergone a rigorous (but generic) development process. Prior to testing the system, the manager *organized a meeting with all staff, including the table, bar and kitchen staff.* (Restaurant owner, 28/7/03). In this meeting the proposed system was explained to staff and they were given the opportunity to participate in the design process, providing feedback about any concerns with regards to the automating of their work and specific user issues which needed to be considered. It is important to note that the system is relatively uncomplicated, only requiring the development of an interface for the restaurant menu and order forms, and no further modification to the already existing systems of the restaurant.

The restaurant manager acknowledged that the system provided almost instant benefits to the business, with further unexpected benefits emerging over time. The benefits described by the restaurant owner and manager were as follows:

- **Greater accuracy in the orders produced**: *...we now have fewer misinterpretations compared with the written orders form.* (Restaurant owner, 28/7/03). This was achieved through the use of check boxes on the PDA interface with the consequence that there was less chance of misinterpretation by kitchen and bar staff (and therefore less incorrect orders).

- **Improved record keeping**: *...all orders are recorded to a database server* (Restaurant developer, 28/7/03) via the wireless network. There is no need to double handle the information, in the form of subsequent data entry from the hand written notes. This resulted in a reduction of recording time, associated cost benefits and improved data integrity.

- **Improved customer service**: The waiter / waitress no longer need to physically move between the table service area and the kitchen or bar. This allows more time for waiting on the customer. It also has the added benefit of providing table staff a greater opportunity to sell more items such as drinks and desserts.

- **A quicker response time to variations in customer orders**: The use of the PDAs has also allowed for faster interaction between table staff and bar / kitchen staff. For example, *if a customer wants to know how their order is progressing then the waiter can make the query from the PDA and tell them more or less straight away.* (Restaurant developer, 28/7/03),

5. APPLYING ACTIVITY THEORY

Here we consider the activity of "delivering the chosen order to the customer". The outcome is presumably a happy (and paying) customer. The subjects, the waiter, the kitchen staff and to some extent the customer, act as a collective to realise the object, the delivered order. For the old system, the activity can be split into the actions shown in figure 1.

ACTION	ACTOR	GOAL	TOOLS
decide order	customer	order choice	menu, specials board, knowledge of cuisine
record order	waiter	recorded order	knowledge of dishes, knowledge of availability, order pad
deliver order	waiter	order at kitchen	order slip, place to deposit order
prepare food	kitchen staff	prepared food	order slip, kitchen equipment, knowledge of cooking, team structure
notify food ready	kitchen staff	inform waiter	bell, order slip, place to deposit food
deliver food	waiter	food on table	order slip

Figure 1 - the Restaurant before

The community can be taken as the organisation of the particular restaurant, plus general aspects of food industry culture (in Australia in this case). The division of labour is clear from the above table (except possibly between customer and waiter in order choice). The rules include the work flow that is implied in the table and industry values that indicate that kitchen staff have higher status than waiters.

With the introduction of the PDA based system the activity is modified to that shown in figure 2.

ACTION	ACTOR	GOAL	TOOLS
decide order	customer	order choice	menu, specials board, knowledge of cuisine, questions from PDA
record order	waiter	recorded order	knowledge of dishes, PDA
prepare food	kitchen staff	prepared food	order printout, kitchen equipment, knowledge of cooking, team structure
deliver food	kitchen staff	food on table	order printout

Figure 2 - the Restaurant after

The PDA is now used to enter the order which is then printed in the kitchen. The most obvious change is that two steps have been eliminated. The waiter does not need to take the order to the kitchen since it is now sent through the wireless network. And the kitchen staff do not need to notify the waiter when the food is ready, since they bring it from the kitchen themselves. The latter change represents a different division of labour. Given the status rules, it is possible that the kitchen staff might resent undertaking this "inferior" action. However, this problem doesn't seem to arise, possibly because the kitchen staff appreciate the opportunity to present their work to the customer. (We didn't actually ask about this; we might have if we had used Activity Theory from the beginning.)

6. ANALYSING THE CHANGE

The changes here were relatively small, with only one change to the division of labour and no significant changes to the rules. The old system was working well and the new technology fitted smoothly into the existing culture.

If we consider the activity of actually introducing the new system, this was also assisted by the "rules" of the restaurant community. Restaurants are usually small businesses where many staff are employed short term and the owner/manager's control is unchallenged. With the owner driving the change there was a good chance of success.

As an aside, we note that we could have specified the object of this activity as "delivering the **desired** order to the customer". This emphasises that a successful outcome depends on water, chef and customer sharing an image of the food that is to be provided. This shared understanding is assisted in some Asian restaurants by the provision of photographs or even models of the items on the menu. The fact that this is not done in other restaurants (and that sometimes the menu is in a foreign language) indicates that the object of the activity might be rather more complex, including elements of atmosphere and status as well as food.

7. UNSUCCESSFUL CHANGE - THE HOSPITAL INTRODUCING MOBILE TECHNOLOGY

The Mobile Hospital Ward System is (at the time of writing) being developed to access information in the 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 to create a paper-based hard copy, early in the morning prior to the doctors conducting their 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 there was no shared database between these collaborators and each was able to update information in the patient record at any point in time. This created a problem, in that if an update was made whilst a ward round is 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 / uneducated 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 patient record printout, then information vital to the health of a patient might be missed or even be a cause of a misdiagnosis.

To address this issue, the case study hospital began trialing a wireless system that would allow doctors to access the up-to-date information whilst on their rounds. The system includes a wireless enabled Tablet PC, which allows the user to write their reports or access data using a sensor pen or a keyboard. IEEE 802.11b is 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 appears on the tablet. As such the interface is exactly the same as the one used to download patient information.

The development of the system included a long consultation process with the users. Training sessions were also organized; however, 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,12/9/03) and as such functionality was purposefully limited

Unlike the restaurant example described above, this system has not met with a high level of success in terms of user adoption. The observed outcomes of this system include the following points:

- The system had been in use for approximately one month. At the time of implementation only one out of the three doctors on the ward had used the system. The doctor who had used the new system had only used it once and then returned to the traditional method. As such, document access is still undertaken using the old process.
- A key issue was security of the equipment. *Unless nailed down any piece of equipment will walk out of here [be stolen].* (Doctor 3, 12/9/03) This point has significantly contributed to the poor success / adoption of the system, as neither nurses or doctors felt prepared to take responsibility for it, if it was stolen during their round.
- The users / doctors were familiar with the technology, already having to interface with a computer to download patient information.

▪   Access to the laptop is restricted to the doctors. The doctors believe that *if everyone else (administration, nurses etc) has access to the laptop then the system won't be available for our use (by the doctors)*. (Doctor 2, 12/9/03)

▪   Having tried the new system (once), one doctor returned to the old system because he felt *more comfortable with it* (Doctor 3, 12/9/03) Norman is quoted as saying that *... 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.* (Norman as quoted in Bergmen, 2000, P18).

▪   The system was perceived to be a useful tool by both the developers and users (even though they weren't using it).

Although the system had been created in consultation with its users, the doctors continued to use the paper based system. Due to a lack of support, this mobile information system for the hospital ward is no longer used.

8. APPLYING ACTIVITY THEORY

Here we consider the activity of "creating an understanding of patient condition". The outcome is presumably better patient care. The subjects are doctors, nurses, medical technologists and administrative staff. For the old system, the activity can be split into actions shown in figure 3.

ACTION	ACTOR	GOAL	TOOLS
update patient record	medical department	recording one aspect of patient condition	test results, access to database
read patient record	doctor	get patient data	patient identification, access to database
deduce patient condition	doctor	image of patient condition	patient record, observation, medical knowledge

Figure 3 - the Hospital before

The community can be taken as the organisation of the particular hospital, plus general aspects of health industry culture (in Australian cities in this case). Here we can see that aspects of this culture are reflected in problems with the analysis represented in the above table. The term "health industry culture" often refers only to the culture of governments, private hospital owners and administrators. The doctors have greater allegiance to the culture of the medical profession, a very strong culture. The nurses also have their own culture, though not as strong as that of the medical profession. The cultural allegiance of medical technologists is unclear. This cultural dissonance means that it is difficult to see the diverse actors as forming a collective oriented towards a common object. The object of the activity would seem to be the "image of patient condition" but the doctors see this as an intuitive cognitive action of which only they are capable. The other actors merely provide some supporting data. This cultural rule prevents the development of any coherent work flow in the activity. It also leads to confusion concerning the division of labour. The division between doctors and others is apparently very clear, but other actions are attributed to the various "medical departments". It is not clear who is actually responsible for these actions, and whether they are technicians, nurses or administrators..

With the introduction of the laptop based system the activity appears as in figure 4.

ACTION	ACTOR	GOAL	TOOLS
update patient record	medical department	recording one aspect of patient condition	test results, access to database
read patient record	doctor	get patient data	patient identification, access to database
deduce patient condition	doctor	image of patient condition	patient record, observation, medical knowledge

Figure 4 - the Hospital after

Strangely, nothing appears to have changed. In recording this activity we have not indicated the hardware used to access the patient record or the time at which this is done. From an HCI point of view this appears to be a serious omission, but from the logic and psychology of the collaborative effort it is not significant. The culture has not changed, so the structure of the activity has been preserved.

9. ANALYSING THE CHANGE

The first thing to note is that, from the point of view of the change agents, the original system was not working in that the doctors may have been using out of date information. The diagnosis of this problem was based purely on the timing of the reading of the patient record, without deeper analysis of the activity. The introduction of the laptop did indeed change the way the doctors performed this action (mainly by increasing stress) but there was no obvious connection between this change and the effectiveness of the overall activity of being aware of the patient condition. The ward doctors had no real image of either the problem or its imagined solution.

This result is consistent with the fact that the change was sponsored and introduced by "outsiders" who, despite extensive consultation, lacked the power or influence necessary for the change to succeed. They produced a technical solution to a non-technical problem, and were bound to fail.

10. HOW CAN ACTIVITY THEORY ADVISE CHANGE MANAGERS?

In the above examples we have used a tabular form to analyse the actions constituting a collaborative activity. Displaying the sequence of actions, possibly to reveal actions that could be removed or reordered, could just as easily be done with other notations, such as dataflow diagrams. The advantage of activity theory is that, by obliging us to explicitly state the actor and goal for each action, we are reminded that goals have a psychological dimension, and must be meaningful and acceptable to the relevant actor. The second example shows another use of activity theory. For the overall activity we need to specify an object, and if this cannot be composed from the goals of the subordinate actions, or the various actors are unable to share its meaning, then there is a serious problem with the system that is supposed to produce the object. Thus activity theory can be used both for design and diagnosis.

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