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The Reconstruction of Portable Computers: On the Flexibility of Mobile Computing in Mobile Activities

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Astract

The remote distribution of contemporary activities has direct implications for the mobility of humans and associated actions. Remote distribution inherently entails parameters such as the mobility of individuals, artefacts, tasks and information; and potential conflicts between objective and personal motives of individuals. The interactions of these parameters bear directly on the range of mobile computing services derivable from the use of these artefacts. Based on an activity-theoretical perspective, this paper presents a discussion of the dynamics of mobile computing services through an analysis of the process of reconstruction of personal digital assistants (PDAs) in a mobility-saturated work-integrated learning project. Upon this analysis, I discuss the flexibility of mobile computing as a direct function of the reconstruction process and propose a conceptual framework for the analysis of flexible mobile computing in mobile activities.

Keywords: reconstruction, activity, flexibility, mobile computing.

1 Introduction

Portable information and communication technologies (ICTs) have invaded us, and human activities are increasingly being mobilised and distributed. Yet the present level of mobility and distribution is so seldom problematised, so often taken for granted within IS research (Sørensen 1999). Mobility presents a significant challenge for IS research which, in the past, has largely concerned itself with desktop ICTs such as mainframe and desktop computers.

More significantly, the remote distribution of contemporary activities has direct implications for the mobility of humans and associated computing actions. Remote distribution inherently entails parameters such as the mobility of individuals, artefacts, tasks and information; and potential conflicts between objective and personal motives. For instance, how professionals' work and learn in distributed environments with portable ICTs, as well as the dynamics of

how they reconstruct these artefacts as they derive mobile computing services have seen little investigation and clarification. This paper takes up the challenge to tease out the dynamics of mobile computing services through an analysis of the process of reconstruction of personal digital assistants (PDAs) in a mobility-saturated work-integrated learning project. It is aimed at theorising the flexibility of mobile computing based on the premise of reconstruction of portable computers.

The next section is a brief discussion of the theoretical framework of the study, followed by a description of the empirical study and its relevant findings. Analysis of the findings follows and concludes with the proposition of a conceptual model of flexible computing.

2 Theoretical Foundations

2.1 Motives and the Theory of Activity

The theory of Activity[1] is a "philosophical and cross-disciplinary framework for studying different forms of human practices as development processes, with both individual and social levels interlinked at the same time" (Kuutti 1995). The main idea presented by the theory is that the relationship between an individual subject and the world is mediated by his or her activities; that is, his or her interactions with environmental objects.

An activity is directed by a motive, and the motive is to transform an object: an activity "answers a definite need of the subject, is directed toward an object of this need, is extinguished as a result of its satisfaction, and is produced again, perhaps in other, altogether changed conditions" (Leont'ev 1978, p.62). The motivation is aroused when the person has identified an object which he or she perceives will satisfy his or her need. The motive is a result of stimulation in the consciousness of the subject by biologically- and sociologically-satisfying external objects; and it gives an activity a determined direction. The motive, according to Leont'ev, may be "either real or ideal, either present in perception or exclusively in the imagination or in thought" (*loc. cit.*). The general macrostructure of an activity incorporates both internal and external activities of the subject; it is constituted by a series of

[1] Although the historical roots of activity theory are traced to various sources by various contemporary authors, it is mostly claimed that its foundation was laid in the cultural-historical psychological works of Lev Vygotsky during the 1920s and early 1930s. However, the understanding of activity in the works of psychologists such as Vygotsky, Leont'ev, Engeström and Il'enkov is inspired by Karl Marx.

conscious and goal-oriented *actions* which are also constituted by subconscious *operations* (see Figure 1).

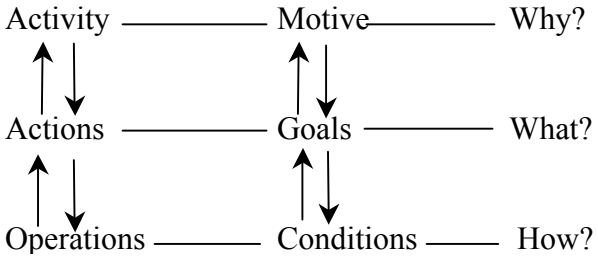

Figure 1: General Structure of an Activity
[Adopted from Leont'ev (1978)].

A series of actions together constitute an activity, and they are conducted through a planning-orientation-execution phase. This implies that actions are performed consciously and are directed at the achievement of immediate or intermediate goals. Generally, goal-oriented actions result in objective products which satisfy the motives by which an activity was stimulated.

Compared with actions that are consciously performed, operations are subconsciously performed. An operation is determined by the goal which is given in certain conditions requiring a certain mode of action; and operations can degenerate into actions when the subject encounters adverse conditions in an activity. The back-and-forth movements and transformation of actions and operations have direct implications for the analysis of the flexibility of computing actions.

2.2 Conditions surrounding Mobile ICT uses in Mobile Activities

The uses of mediating physical and psychological tools may constitute activities, or may constitute actions and operations of an activity depending on the pertaining conditions. In other words, the analysis of mediation by physical instruments has to open up to the fact that the instrument can assume any of the activity levels depending on several other environmental conditions that impact directly or indirectly on the activity. The identification and analysis of the dynamic properties of physical tools are particularly important when one considers the complexity of modern portable ICTs. To understand this problem, we draw upon Kristofferson and Ljungberg's (2000) argument that the utility of portable ICTs is dependent on three factors – modality, environment and application. The immediate nature of

the physical and social surroundings defines the environment; applications represent the design properties of ICTs such as hardware, software and data; and modality stands for the fundamental patterns of human movement. Thus, the ease and/or clumsiness of their uses are, primarily, factors of conditions represented the modalities of human mobility and their affordances (physical, interface and system design properties).

Modality, in the sense of Kristoffersen & Ljungberg (2000) is the description of the "fundamental patterns of motion" of humans as they move around – travelling, visiting and wandering. Travelling is the process of movement from one point to another in which the distance between those two points is such that a vehicle is required to convey the person in the process. Visiting demands some form of travelling but its essential component is the prolonged time a person spends at one location to perform some function before moving to another location. A wanderer is a person whose movements exhibit "extensive local mobility in a building or local area" (*ibid.*, p.142). He or she does some limited travels and visits in a localised environment. These fundamental patterns represent a modest and simple functional characterisation of the complexly variegated nature of human mobility; however, they are useful in the sense of their intrinsic linkage with portable ICTs and the conditions of their use.

According to Gibson, the affordances of an object of the environment, natural or artificial, are the perceptible properties it "offers the animal, what it provides or furnishes, either for good or ill" (1979, p.127). Affordances point to both the environment and the observer, and are realised in the interaction between organisms and environmental objects.

> "An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behaviour. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer" (*Ibid.*, p. 129).

For ICTs that have numerous hidden affordances for information capture, processing and transmission, their ease of use is very much dependent on perceived ease of use in action. Therefore, "[m]aking affordances perceptible is one approach to designing easily-used systems" (Gaver 1991, cf. Draper 1986). It follows from this that ICT affordances are derived from their physical, interface and system design properties as well as on the user's socio-cultural experience.

Socio-cultural experience is premised on the objective and social sense of external objects as demonstrated in Il'enkov's (1977) analysis of the concept of the *ideal*. The ideal is a sign or symbol historically and culturally built collectively by society for society which mediates human activities. The ideal

> "…confronts the individual as the thought of preceding generations realised ('reified', 'objectified', 'alienated') in sensuously perceptible 'matter' – in language and visually perceptible images, in books and statues, in wood and bronze, in the form of places of worship and instruments of labour, in the designs of machines and state buildings, in the patterns of scientific and moral systems, and so on. All these objects are in their *existence*, in their 'present being' substantial, 'material', but in their *essence*, in their origin they are 'ideal', because they embody the collective thinking of people, the 'universal spirit' of mankind" (Il'enkov 1977)[italics mine].

Thus, there is a distinction between crude material matter of natural origin and idealised material of socio-cultural origin built through collective sense-making of people.

These parameters – motives driving an activity, technology affordances, and modalities of human mobility – have some bearing on the degrees of reconstruction of ICTs by users, and reflect the enabling and limiting capacities of ICTs.

2.3 Technology Reconstruction

Reconstruction of technology is based on a user's teleological "assignment – or imposition – of function" to the artefact (Searle 1995, p.14); and it is the accumulation or individual reconstructions that evolve into a socially shared understanding seen as a social construction (cf. Searle 1995, Berger and Luckmann 1967). The enabling and limiting capacities of ICTs can be situated within arguments founded on technological determinism and social constructivism which provide contrasting insights about the nature of technology in human activities. Technological determinists (e.g. Winner 1993, 2001, 1977) argue in favour of the imposing nature of technology; that technology invites human action and not the other way round. Thus, one can perform many actions with a car, but he or she cannot fly the car like an aeroplane. The social constructivists (e.g. MacKenzie and Wajcman 1985, Orlikowski 1992, 2000, Bijker 2001, Bijker *et. al.* 1987, Woolgar 1991), on the other hand, argue for the supple nature of technology systems based on the social context of use.

While the technological determinists seem to base their arguments mostly on the design properties of technology, the social constructivists seem to base their arguments on the activity- or context-based interpretation of the design properties of technology. But

technology possesses both determining or limiting and socially constructed or enabling properties. Technology is both imposing and flexible, both a determinant of actions and socially constructed.

It is reasonable to say that actions are constrained by the physical properties of technology, and moreover the "situated use of technology is confined to a set of predefined options and reflects the instantiation of a context-free logic embedded in the artefact" (Kallinikos 2002). However, it is also reasonable to say, at the same time, that an overemphasis of technological determinism can be misleading because technology is interpretively flexible. Bijker (2001), for example, argues that "this *interpretive flexibility* …shows that neither an artefact's identity nor its technical 'success' or 'failure', are intrinsic properties of the artefact but subject to social variables" (p.26). This implies that particular affordances of an artefact and the modalities in which it is used can induce a flexible interpretation and reconstruction of the its properties.

3 Mobile Computing in Mobile Work-Integrated Learning: An Empirical Study

3.1 Information Management through Mobile Computing

I undertook a 12-month empirical study of mobile computing in a work-integrated learning (WIL) project in the UK NHS[2] from April 2003 to understand the complexities of portable technology use in mobile activities.

It was a pilot project in which twelve health professionals were being trained for a new professional role in surgical care. The new role was being created to fill an impending man-our or skills shortage gap which would be left by junior doctors as their weekly hours were being cut from an average of 72 to 56 by the European Union Working Time Directive (EUWTD).

The project was characterised by remote distribution and mobility – of the twelve trainees/learners, of the learning activity, of the PDAs, and of information. It entailed both local mobility within each learner's hospital and remote mobility to and from the training coordination centre in London. In the parlance of Kristoffersen and Ljungberg (2000), these

[2] National Health Service of United Kingdom.

forms of mobility are respectively conceptualised as wandering and visiting. PDAs were officially adopted and deployed to provide computational support for this activity. Particularly, the highly critical issues of monitoring and remote control of the learners' activities in their individual hospitals and the development of learning portfolios were the targets of the computing support.

Remote monitoring and control of clinical actions, and the development of portfolios of evidence of those actions undertaken were requirements whose fulfilments were aimed at satisfying two parties. First, the sponsors of the project, the European Union, had to be fed with reports and statistics of proceedings of the training project. These reports would convey the details of the activities that were actually undertaken by the learners in their hospitals with the aim of underlining the credibility of the whole training exercise and hence of the new professional role. Second, the wider community of existing medical professionals had to be satisfied that this new professional role was credible. Since professions in the medical field have existed for centuries, the success of this new profession depended on the acceptance and trust given by existing medical professionals. Thus, the portfolios were meant to provide evidence of the depth and breadth of learning activities undertaken by the learners in the instance where anyone doubted their relevance.

Each learner was provided with a Compaq iPAQ H3970 model PDA which was running a Pocket PC 2002 operating system. Each was also given a foldable keyboard to facilitate their input of written reflections-on-action (Schön 1983) onto the PDA. This PDA model has an inbuilt appointment calendar, address book and limited or 'pocket' versions of Microsoft® Word® and Excel® and Outlook®. These were deployed to be used by the learners as tools for capturing information on the spot, for reading information, for recording clinical and learning activities, for writing reflections right after every learning activity, for sharing information, and for transfer of relevant data to the monitoring centre in London. They were supposed to be used to process notes and other information while roaming from one ward to another and in other locations of their hospitals as their training demanded. Their learning processes demanded that it was crucial to record what was done when it was done, not at the end, and the PDAs were deployed to fulfil immediate and easy capture and processing of information.

An activity Logging database that held recorded details of patient encounters on the wards was to be developed by each trainee. Clinical activities were to be selected from a predefined 'pick list' through tapping a stylus directly on the PDA screen. Additional data included details such as the initials of any supervisor and whether a perfomed activity was an elective or emergency. The patient's age and gender were recorded but in accordance with data protection legislation their names were not.

There was also a learning Reflective Journal which consisted of a set of templates with headings such as "thoughts and feelings?" and "what worked and what didn't?" These were intentionally open-ended questions which would allow the learners to frame the answers as they wished. Answers to these questions were to be typed as reflections-on-actions at the end of each learning day using the foldable keyboard.

It was envisaged that the PDAs would provide learning support to the learners through the accumulation of relevant learning resources – medical literature, drug calculators and formulary[3] – which could be available to the learners anywhere during their learning manoeuvres. Although access to learning resources was implemented six months into the project, it eventually became the key factor that sustained any hope which the learners had in the PDA. Compared with the scenario in which learners have to make visits to libraries to gain access to learning resources, or the one in which the learner burdens him- or herself with the task of carrying paper versions of those resources, the PDA would alleviate such problems by saving the time to visit a library and the effort to carry many books while roaming. It was envisioned that when a PDA is inscribed with theoretical medical information and used in practical learning environments, the user/learner could intermittently refer to this information to shape his- or her meaning-making from the practical clinical actions.

3.2 "Failure" and "Success" Perceptions

As far as the training project was concerned, the PDA and all the custom applications that were designed to provide mobile computing support for the learners were deemed as a failure after the implementation period. The artifact could not be used in the clinical setting because of both design and environmental conditional problems. The systemic design of the PDA

[3] British National Formulary was the particular formulary in this instance.

itself was a major limitation – low level processors, slower to manipulate, smaller memories and limited input mechanisms are typical examples. This in turn affected the custom applications that were designed into them. In the end, the highly mobile nature of their clinical duties around the hospital wards ensured that contemporaneous mobile computing was not feasible or possible.

For example, the performance of a typical clinical action such as taking a surgical patient's history could not happen contemporaneously with logging of actions into the PDA. Nor could the learner, in the event when he or she was in the company of the surgical team examining patients in the wards, be audacious enough to pull out his or her PDA from his pocket to read, take notes or log in his or her actions. Apart from the issue of audacity, experiential learning – which relies on direct practice and observation – would not take place in such an instance. From the perspective of interaction, the outcome of Sørensen and Pica's (Forthcoming) study of police work in the UK corroborates the fact that portable ICT use on-the-move occur in "rhythms" between "physical and virtual contexts of work". In other words, more physical work undermines virtual working with a portable artefact and vice versa. It was therefore not surprising when the project manager officially called for the abandonment of the PDA as a tool of information management in the project.

Alongside the failure perception, the learners reported that the PDA was an excellent personal organizer which many of them could not "live without." These reports were received during and after the project. It was clear that the custom applications – such as calendar, task scheduler and address book – had proven to be extremely useful as far as their personal organisation alongside their learning activities were concerned. In the final analysis, the learners were ambivalent towards the PDAs.

4 Analysis: Flexibility of Mobile Computing

In respect of this brief case description, the intriguing question is *what are the dynamic conditions which engendered the success-and-failure perception of mobile computing services?* First and foremost, it has to be noted that whether a portable ICT is perceived to offer any mobile computing service at all depends on a combination of three factors – the *affordances* of the artefact, the *modalities* of human mobility, and the *motives* that engender their uses (Wiredu 2005). The degrees of influence of these factors are dynamic: for example

affordances are dependent on factors such as experience and previous socio-cultural information; modalities of mobility appear in various forms from extremely remote to local; and changing conditions and needs of people induce them to switch motives. Although the case clearly shows that the design properties of the PDAs offered few affordances, and that mobile computing was inflexible and a failure in the project, it is noteworthy that the learners' final evaluation and perception of the PDA as a "wonderful" tool was indicative of its satisfaction of their other personal motives. In order to unveil the dynamics underlying the success-and-failure perception of the artefact, it is interesting to analyse the reconstruction of the artefact, based on its "interpretive flexibility" (Bijker 2001) within the trajectory of its use, and within the confines of the artefact's deterministic design properties.

4.1 Ideality and Reconstruction of the PDA

The trajectory of use of the PDA was situated within the learners' mutating perception of the PDA as a *tool* or *object* depending on the activity and motive on the one hand, and flexible use on the other hand. As a tool, which was what it was envisioned to be from the outset, it would figuratively represent a transparent screen through which the subject could see his learning object and transform it. As an object, it would represent an opaque device standing in-between the subject and object: its use would represent another activity existing alongside the learning activity. Evidence from the project suggested that, in terms of the central activity, the device represented an object, an opaque piece of equipment, which interfered with the learners' clinical routines and contravened its initial tool-functionality. The source of this problem is to be found precisely in the idealisation of the PDA; that is, the design of PDAs and the marketing gimmicks that promote their diffusion, which influenced their adoption and deployment in the project.

Over the years, the gap between expected and actual use of ICTs have founded many accounts of information systems failure. Expectations of technology success, usually conceived before expensive technology integration projects, are largely informed by the pseudo accomplishments of such technologies. Such information results from the conception of the ideal PDA, of either designers' and hence marketers' touted ease of use or accounts from successful use in entirely different contexts. In the work-integrated learning case, the integration of the PDAs was a result of their perceived ease of use to support activity logging and reflections writing in distance and distributed learning. Since this ideal is a reflection of

the designers' construction of these artefacts, and thus their motives, the "social variables" ((Bijker *et. al.* 1987) within the use conditions engendered processes of reconstruction of the PDA and re-conceptualisation of its ideal.

The ideal or "essence" (Il'enkov 1977) of PDAs, at the outset of the project, was a simple extrapolation of the ideal functionalities of desktop computers – their "automating", "informating" and "transformating" capabilities (Zuboff 1988). Stated differently, the PDA is itself a portable prototype of a desktop computer inputted with miniature versions of desktop computer applications. Even in certain respects, the portability of the PDA gives it an added advantage over desktop computers. One of such respects is its mobility, and hence its ostensible facilitation of mobile computing. Here was an extremely volatile and ambitious training project which implementation would undoubtedly be characterised by crucial challenges. It would be work-integrated, activity-based, conducted in distant and distributed locations, function under the direct control of surgical staff and hence out of immediate control of the project team, highly locally mobile, confrontational, unstable and slippery. Since it was a distance and distributed learning exercise, it was imperative for the project team to institute measures to control – to scaffold, monitor and coordinate – the learners' distant activities. Upon this, the adoption and deployment of the PDAs, based on their ideal, was deemed an efficient controlling and stabilising measure.

An intriguing aspect of the evidence from the PDA use over the period was its simultaneous rejection and acceptance by the learners. Its non-utility in the clinical setting, software problems and data losses together caused its eventual formal abandonment in the project. As far as the learning activity was concerned, the ideal PDA proved to be illusive in its utility. However, the uses of its generic or standard applications at the personal level proved to be a fantastic experience, a tool that many of them could not "live without". Thus, while the perception of the PDA as a learning support tool in the project was a failure, the same device was deemed a success as far as their standard or factory-built applications were concerned. Even at the end of the project, by which time the PDA had long been abandoned, the learners found the PDAs useful, but this usefulness lived alongside prior disappointment, signifying ambivalence. It is within this ambivalence, based on the social variables in the context of use, that reconstruction of the PDA is attributable.

To begin with, the fact that the success of a PDA manifests in its usage as an action or operation rather than activity, leading to its perception as a tool rather than an object, has to be emphasised. In other words, the flexibility of mobile computing determines its successful use. To be sure, evidence and accounts of ICT failures coupled with the efforts of IS developers attest to the fact that technology users instinctively desire and strive continuously towards a state of flexible computing. Over the course of the work-integrated learning project, this striving for flexibility on the part of the learners was obvious; and circumstances of low flexible computing, symbolising failure, were continuously being substituted for higher flexible computing. Given that the project-use of the PDA was deemed a failure and personal-use a success, the process of reconstruction from 'uselessness' to 'usefulness' was situated within the continuum between these two sets of uses (see Figure 2).

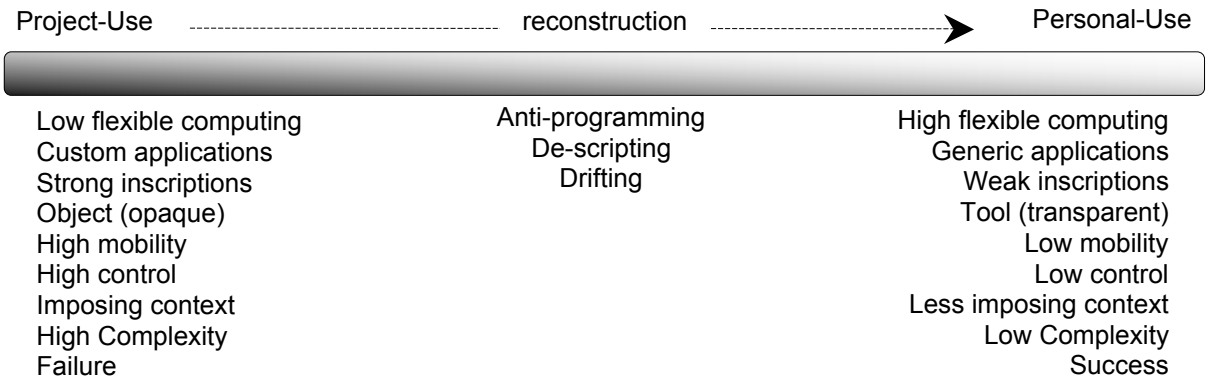

Figure 2: Reconstruction of the PDA.

Specifically, reconstruction was rooted in and embodied by the strength of inscriptions (Akrich 1992) of the original designers and of the project manager. The framework of learning actions and reflections, which underpinned the design of HanDBase, abcDB and the pocket Word® and Excel® applications, was grounded on pedagogical principles to surrogate the project manager's monitoring and instructions from the training centre in London. Given the strong focus of the project on surgical care skills acquisition towards the assumption of junior doctors' functions, and the aim to satisfy accreditation and acceptability requirements, the pedagogical principle underlying the clinical actions and reflections framework was instructive and objectivist-oriented. Hence, the applications that emanated were characterised by strong inscriptions of the project manager's desired patterns of

expected use by the learners. These attributes of instructive learning – such as monitoring, scaffolding, and facilitation – were all inscribed into the PDAs based on implicit and explicit assumptions about the technology's capacities, its ideal capacities, for providing mobile computing services. The automation of these attributes, the strong inscriptions, because they were imposing on the users, and because they added to existing structures represented by the PDA's design properties and the learning conditions, exemplified high "complexity" and an overload of "structures" (Sørensen *et. al.* 2002). In short, the PDA could not be idealised as it was desired. In reality, "anti-programming" (Latour 1991), "de-scripting" (Akrich 1992) and "drifting" (Ciborra 2000) were inevitable.

Instead of activity logging after the completion of every action, the learners, on realising the clinical impracticality of such actions, used paper-based logging sheets and later transferred these into the PDA when they returned home. Instead of writing reflections-on-action at the end of every day's learning, most of them wrote them weekly; worse still, they wrote on paper before typing into their PDAs. Worst of all, many of them even found it more convenient to perform these computing actions on their desktop computers and subsequently synchronise them into the PDA. It was clear that the learners were following an "anti-programme". These counter-actions were performed to alleviate the imposition and intrusion associated with the custom application; that is, they were "de-scripting" the inscribed remote-controlling measures of the project manager – not rebelliously, but in their instinctive orientation towards flexible computing.

The failure of the technology under the custom applications and its success under the standard applications suggest that the learning conditions were more accountable for anti-programming and de-scripting than the design properties. These conditions contained the "social variables" upon which, Bijker (2001) conceptualises the "interpretive flexibility" of technology. In truth, the learners' interpretation of the applications built into the PDA, leading to a mix of success-and-failure perceptions, was premised on whether the learning actions allowed flexible computing or otherwise. In low flexible computing, the PDA was an object. As an object, if it ever satisfied a need, the learners' motive to transform it was implicit in its reconstruction into a tool; and its tool perception reflects highly flexible computing which, in the learners' case, could only be accomplished in less mobile and less imposing conditions – at home or after work, for instance. Reconstruction was witnessed in a

"drift" from 'uselessness' in objective circumstances towards successful personal-use. Wartofsky (1979) argued similarly:

> "On this reconstruction, we may speak of a class of artefacts which can come to constitute a relatively autonomous 'world,' in which the rules, conventions and outcomes no longer appear directly practical, or which, indeed, seem to constitute an arena of non-practical, or 'free' play or game activity. (...) So called 'disinterested' perception, or aesthetic perception, or sheer contemplation then becomes a possibility; but not in the sense that it has *no use*. Rather, in the sense that the original role of the representation has been, so to speak, suspended or bracketed." (p.208).

It is exactly the phenomena of "suspension" and "bracketing" which characterised the reconstruction of the PDA. Of course the PDA ended up as a tool; but a tool for other personal activities and motives of the learners contrary to the originally purported tool function of the learning activity. To wit, at the collective level of the twelve learners, it was clear that the PDA had been socially constructed – personalised and reconstructed at the individual level – into a useful and successful tool.

It is therefore argued that the set of conditions of an activity, which determine the flexibility of mobile computing, must be the focal point of determining whether an artefact offers any mobile computing service. On the balance of the flexibility of mobile computing in the project, the PDA offered optimum computing services during its use in less "frustrating" (Ortega y Gasset 1941) conditions, that is, when it was being used to fulfil personal motives.

5 Human Mobility and Flexible Computing: A Conceptual Model

The preceding arguments shape up into relationships between the various factors which have dominated the analysis – human mobility, motives, conditions, ICT affordances, and flexibility of mobile computing. These relationships are condensed into a conceptual model which suggests a path for analysing mobile computing in human activities and for ascertaining the flexibility of mobile computing. In view of the murky nature of the concept of 'mobility', it is necessary to develop this conceptual model to ground the analysis of the impact of portable ICTs as mediators in human activities. Thus, the whole concept of mobility, in terms of portable ICTs and mobile computing, is properly dissected to depict its constituent levels and their interrelationships between these levels (see Figure 3).

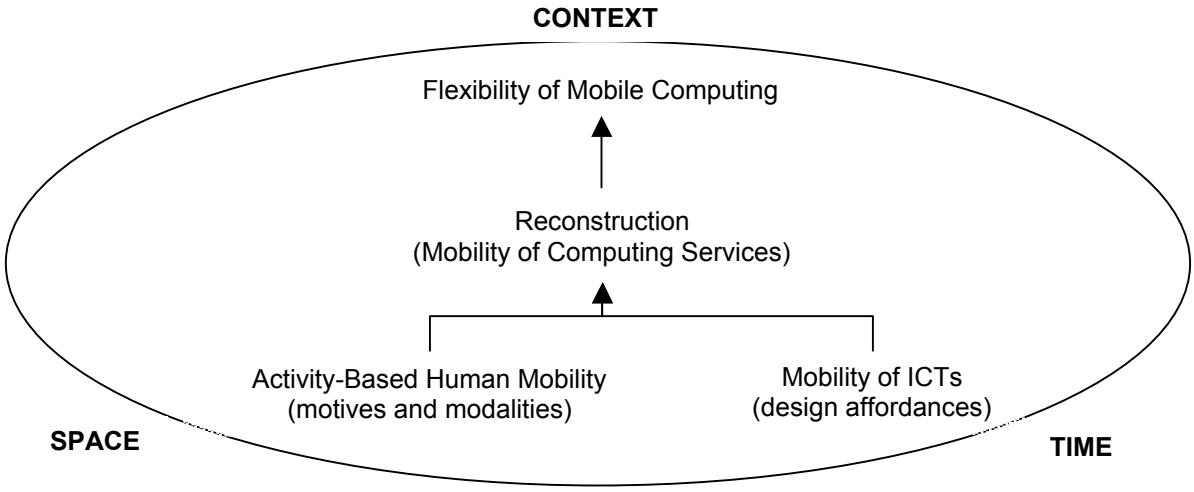

Figure 3: Conceptual Framework for the determination of Flexible Computing from Mobility of Humans Activities and ICTs.

The spatial, temporal and contextual dimensions of mobility are fundamental and inseparable: all other forms, types or modalities of mobility can be properly understood along the lines of a combination of their space, time and context dimensions. This inseparability is depicted by the oval that embodies the mobility levels in Figure 3.

It is well known that human mobility is most fundamental due to the purposeful movement of humans caused by their biological and environmental needs. An aspect of this idea can be found in Wiberg's (2001) argument that human mobility is inspired by the social need to interact. While human mobility is basic, an understanding of the mobility of ICTs cannot be achieved when human and object mobility are separated. In other words, since portable ICTs are incapable of self-mobility, understanding their impact relies on understanding the modalities of human mobility that engender the mobility of ICTs: the mobility of ICTs, in the context of purposeful human activities, is always dependent on human mobility. Even though self-moving robotic machines seem to be exceptions, we have to remember that humans design the machines that enable them to exhibit self-mobility. The inseparability of human and object mobility is a result of the ontogenetic and phylogenetic development efforts of individuals and society which stimulate human activities (see Vygotsky 1962, 1978, Leont'ev 1978, 1982, Marx 1909). Objects are either the targets or mediators of human activities, thus they are always intrinsic aspects of activities which embody human movements. Human and object mobility therefore serve as a substrate upon which other forms of mobility develop or depend.

Mobile computing services comprise the next level of mobility and are direct resultants of the mobility of ICTs and the conditions within those activities they mediate. Note that whether a portable ICT is perceived to provide any mobile computing service at all depends on a combination of three deciding factors – the *affordances* of the artefact based on its physical, systemic and interfacial design properties, the *motives* that engender their uses, and the *modalities* of human mobility. These three factors can be derived from a task-technology fit (Goodhue and Thompson 1995) analysis of activity-based human mobility and technology-in-use at the base level of the model.

It may therefore be misleading to argue simplistically that portable ICTs automatically provide mobile computing services. Mobile humans carry portable ICTs to draw on their computing services potentiality for satisfying particular motives in their activities; if the affordances of the ICT, the motives of those activities, and the modalities of human mobility exhibited make it impossible to draw on the information services, then the ICT virtually becomes a white elephant and this engenders the reconstruction process. Since mobile human activities are performed within changing dimensions and modalities of mobility, the degree of accessibility of mobile computing services within mobile artefacts for supporting mobile activities vary considerably (cf. Wiberg and Ljungberg 2001, Weilenmann 2001). Accessibility resonates well in reconstruction because it is one of reconstruction's key attributes.

Based on the state and quality of mobile computing services that can be obtained from portable ICTs, the flexibility of mobile computing can be deciphered. In the work-integrated learning case, accessibility to computing services shaped the reconstruction and personalisation of the PDA leading to our determination of how flexible mobile computing was. Furthermore, it is the determination of this flexibility which informs on the transformative impact of a particular ICT in an activity. Portable ICTs mediate activities and transform them into technology-mediated activities. A typical example is the technology transformation of learning into technology-mediated learning (e.g. Alavi and Leidner 2001) and mobile learning which is increasingly attracting attention in current technology-mediated learning research. Work is also increasingly being mobilised in various forms leading to current popular themes such as occupational mobility and mobile professionals (Kakihara and

Sørensen 2002b), nomadic working (Dahlbom 2000), tele-activities (Castells 2001), and e-lancers (Malone and Laubacher 1998). However, mobile computing services are not automatic enhancers of mobile activities (see Weilenmann 2001, Wiberg 2001). In fact they can be corrupters of those activities, just as the technologising of the word, espoused by Ong (1982) and Fichtner (1985), could possibly lead to rote and unproductive learning.

6 Conclusion

To conclude, for the purposes of analysing the utility of portable ICTs in purposeful human activities, the mobility levels presented in the model (Figure 3) is valuable. It places the analysis of mobile information services and reconstruction in a pivotal position, brings the complexities and complications associated with portable ICTs' uses in human activities into focus, and displaces the tendency to oversimplify its problematic nature. The model proposes a shift in perspective from focusing on the factory-based design properties of portable ICTs for making judgements about their utility towards a focus on the mobile computing services they offer in human activities. Hence, it is in the analysis of the reconstruction of the artefact – the causes by affordances, motives and modalities of mobility, as well as the enhancing or debilitating effects on those activities – that will unearth a clearer understanding of the flexibility of mobile computing. This is the most effective way of informing the design of portable ICTs for mobilising human activities.

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